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SPRAY CHARACTERISTICS AND TAKE-OFF AND LANDING STABILITY OF SEVERAL MODIFICATIONS OF A 1/8-SIZE MODEL OF THE PBN-1 FLYING BOAT - NACA MODEL 192

By David R. Woodward and Howard Zeck

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NACA

WASHINGTON

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MEMORANDUM REPORT

for the

Bureau of Aeronautics, Navy Department

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SUMMARY

Several modifications of a 1/8-size model of the PBN-1 airplane were tested in Langley tank no. 1 to determine their effect on the spray characteristics and on the take-off and landing stability. The modifications included changes in the bow (addition of spray strips) and increases in the depth of step and angle of afterbody keel.

The spray over the bow at low speeds was reduced by the addition of spray strips and, to a lesser extent, by an increase in depth of step or angle of afterbody keel. The range of speeds over which spray entered the propellers was reduced by the addition of spray strips. An increase in depth of step, which increased the propeller clearance, also reduced this range of speeds. An increase in angle of afterbody keel had little effect on the propeller spray.

The basic model skipped at all trims above 6°. This skipping was eliminated by an increase in the depth of step from 3.8 to 7 percent beam. An increase in the angle of afterbody keel from 6.25° to 7.75° reduced the landing stability. The location of the main step was satisfactory for stable take-offs with neutral elevators at forward positions of the center of gravity and with -10° elevators (trailing edge up) at after positions of the center of gravity. An increase in the depth of step or angle of afterbody keel did not appreciably affect the forward limit for stable positions of the center of gravity. With an elevator deflection of -10°, the after

limit for stable positions of the center of gravity was moved aft when the depth of step was increased.

INTRODUCTION

The tank tests of a 1/8-size model of the PBN-1 airplane described in this report were requested by the Bureau of Aeronautics, Navy Department, on May 27, 1943.

The PBN-1, which is built by the Naval Aircraft Factory, is a modified version of the PBY airplane. Flight reports indicate that the spray characteristics of the PBN-1 are not entirely satisfactory. At very low speeds the spray comes over the bow and wets the windshield, and at a slightly higher speed spray strikes the propellers. The airplane also tends to skip on landing. Tests of a powered dynamic model were made to determine the effect of spray strips, depth of step, and angle of afterbody keel on the spray characteristics and on the take-off and landing stability.

The investigation was made in Langley tank no. 1 in October and November of 1944.

DESCRIPTION OF THE MODEL

A 1/8-full-size dynamically similar model of the PBN-1 was constructed at the Langley Laboratory, using drawings and dimensions furnished by the Naval Aircraft Factory. The principal dimensions of the model are given in table 1. The general arrangement of the model is shown in figure 1, and a photograph of the model is presented in figure 2.

The main differences between the hull of the present model and that of the PBY are shown in the following table:

	PBY	PBN-1 (model 192)
Plan form of step	Transverse	20° vee
Depth main step at keel, percent beam	3.4	3.8
Depth of step at centroid, percent beam	----------	2.6
Bow to main step, inches	38.13	38.67(to centroid)
Step location, percent M.A.C.	59	52.5(at centroid)
Main step to second step, inches	23.2	31.46(from centroid)

The lines of the bow of the full-size PBN-1 were formed by refairing the bow of the PBY airplane and installing clamshell doors over the bombardier's window.

The hull of the model was built in three parts to facilate changes in the bow, the depth of step, and the angle of afterbody keel. Two bows were constructed: the original PBN-1 bow, and a similar bow with spray strips added at the chines (figs. 3(a) and 3(b)). Two afterbody sections that differed only in the angle of afterbody keel (6.25° and 7.75°) were provided. The depth of step was increased by lowering the bottom of the forebody.

The power installation consisted of two 0.9-horsepower direct-current electric motors which turned three-blade metal propellers. The propellers, which had a diameter of 18 inches and a blade angle of 17°, were turned at 4335 rpm to obtain scale thrust.

Slats were attached to the leading edge of the wing in order to delay the stall and compensate for scale effect on lift coefficient.

A list of the configurations that were tested and the corresponding model designations is presented in the following table:

Model no.	Bow	Depth of main step at keel, percent beam	Angle of afterbody keel (deg)
192	PBN-1	3.8	6.25
192A	PBN-1 with NAF spray strips	3.8	6.25
192A-1	-------do-------	7.0	6.25
192A-2	-------do-------	10.0	6.25
192B	-------do-------	3.8	7.75
192B-1	-------do-------	7.0	7.75

The following values for the moment of inertia of the ballasted model were obtained:

Horizontal position of the center of gravity, percent M.A.C.	Moment of inertia, slug-feet^2
20	3.89
30	3.89
40	4.09

APPARATUS AND PROCEDURE

The towing equipment and some of the testing methods used in Langley tank no. 1 are described in reference 1. A description of the test procedure used for this investigation is presented in reference 2.

The following conditions were maintained for all of the tests, unless otherwise specified:

Design stabilizer, δ_s, -2° to the wing chord
Leading-edge slats on wing
Deflection of elevators, δ_e, 0°
Position of center of gravity
  Vertical position 15.25 inches above keel at step
  Horizontal position, 28 percent M.A.C.
For tests with power
  Two 18-inch, three-blade metal propellers
  Blade angle, 17°
  Rpm, 4335

The trim was referred to the base line of the model and this angle is measured between the base line and the water plane. Bow-up angles and moments tending to raise the bow were considered positive.

The thrust was measured at a trim of 0° with the model towed just clear of the water. Without power, the aerodynamic lift and pitching moments were measured at a speed of 45 feet per second. With power, aerodynamic tests were made over a range of speeds from 0 to 45 feet per second. The aerodynamic lift and pitching-moment coefficients, computed from these data, are defined as follows:

Lift coefficient, $C_L = \dfrac{L}{\frac{\rho}{2} SV^2}$

Pitching-moment coefficient, $C_m = \dfrac{M}{\frac{\rho}{2} SV^2 c}$

where

L lift, pounds

M pitching moment, pound-feet

ρ density of air, slugs per foot^3

S area of wing, feet^2

V carriage speed, feet per second

c mean aerodynamic chord, 1.72 feet

The effective thrust was computed using the following expressions:

$$T_e = (T - \Delta D) = D + R$$

where

T_e effective thrust, pounds

T propeller thrust, pounds

D drag of model without propellers

ΔD increase in drag due to slipstream, pounds

R measured resultant horizontal force, power on, pounds

An investigation of the bow spray of several modifications of the model was made through a speed range from 0 to 15 feet per second, with full power, at a gross load of 71.7 pounds (37,000 pounds full size). Still photographs were taken at constant speeds, and motion pictures were taken during accelerated runs in both smooth water and in waves 3 inches in height.

The trim limits of stability and the limits for stable positions of the center of gravity were determined for models 192, 192A-1, and 192B-1 with full power at a gross load of 60.1 pounds (31,000 pounds full size). Elevator settings of 0°, -10°, and -25° were used in these tests.

The landing stability of models 192, 192A-1, 192B, and 192B-1 was determined for a trim range from 4° to 16°. The landings were made without power at gross loads of 60.1 and 71.7 pounds. Landing stability was investigated at two positions of the center of gravity, 24 and 34 percent mean aerodynamic chord. Trim and rise records were obtained to show the behavior of the models during landings.

RESULTS AND DISCUSSION

Aerodynamic tests.- The effective thrust, with a blade angle of 17°, and an rpm of 4335 approximated the estimated scale thrust of the airplane. These data are plotted in figure 4 along with the air drag of the complete model.

The aerodynamic lift and pitching-moment coefficients, without power are shown in figure 5 for elevator deflections of 0° and -25°. The aerodynamic lift and pitching moment, with power, are plotted against speed in figure 6 for elevator deflections of 0°, -10°, and -25°. The aerodynamic lift and pitching-moment coefficients, computed from data taken with power at a speed of 45 feet per second, are shown in figure 7.

A comparison of C_L and C_m for neutral elevators, with and without power, is shown in figure 8. The maximum lift coefficients, without power, was 1.65 at a trim of 14.5°, and the lift coefficient at the same trim, with power, was 2.05. With neutral elevators, the application of power did not appreciably change the aerodynamic pitching-moment coefficients.

Spray characteristics.- At low speeds, the spray over the bow of the basic model 192 (fig. 9) was reduced when the spray strips were added (fig. 10). By increasing the depth of step (lowering the forebody), and increasing the angle of afterbody keel, the trim of the model was increased and small decreases in the spray over the bow were observed (figs. 10 to 14).

Representative photographs (figs. 9 to 14) were selected to cover the range of speeds showing spray through the propeller disks. This range, which extended from $8\frac{1}{2}$ to 13 feet per second for the basic model 192, was reduced to a range from $9\frac{1}{2}$ to 13 feet per second when the spray strips were added (fig. 15(a)). Increasing the depth of step which also increased the propeller clearance of model 192A caused successive reductions in this speed range, finally narrowing to a range from 11 to 12 feet per second for a depth of step of 10 percent beam (fig. 15(c)). Increasing the angle of afterbody keel of model 192A increased the trim, but did not appreciably affect the speed range over which the spray was in the propeller disks (fig. 15(b)). The comparisons given in figure 15(d) indicate that the range of speeds over which spray entered the propeller disks was influenced more by the change in propeller clearance than by the change in trim.

Accelerated runs in waves approximately 3 inches high showed trends similar to those found in the tests in smooth water.

Trim limits of stability.- The trim limits of stability for the basic model are shown in figure 16. The range of stable trims was approximately 7°, between the lower limit and the upper limit, increasing trim. The difference between the two branches of the upper limit varied from 1.5° at intermediate planing speeds, to 5° at high speeds. Near getaway speed, model 192 porpoised violently, and the upper limit, decreasing trim, was about 2.5° above the lower limit.

The trim limits of stability for models 192A-1 and 192B-1 are presented in figures 17 and 18, respectively. A comparison of these trim limits with those for model 192 is shown in figure 19. The upper limit, increasing trim, was raised when the depth of step was increased (compare models 192 and 192A-1). This limit was further raised when the angle of afterbody keel was increased (compare models 192A-1 and 192B-1). Over most of the speed range where high-angle porpoising occurred, the difference between the upper limit, increasing trim, and the upper limit, decreasing trim, was smaller and

the porpoising was less violent for models 192A-1 and 192B-1 than for model 192. Within the accuracy of the tests, the lower trim limits of stability of the three models were in agreement.

Stability during take-off.- The variation of trim with speed for model 192 with elevator deflections of 0°, -10°, and -25° is shown in figure 20, and for models 192A-1 and 192B-1 in figures 21 and 22, respectively. Where only one-half cycle of porpoising was encountered at high trims just before take-off, the trim curve is shown as a broken line. With neutral elevators, the trim tracks above humps speeds were approximately the same for the three models. No change in the trim tracks would be expected with neutral elevators inasmuch as the trims were low and the afterbody was clear of the water. With up elevators (-10° and -25°), however, the trim tracks were raised when the depth of step was increased; and the trim tracks were further raised when the angle of afterbody keel was increased (compare models 192A-1 and 192B-1). At the trims obtained with up elevators the afterbody was in the water at high speeds and the trim was therefore influenced by changes in the afterbody clearance.

The maximum amplitude of porpoising of model 192 is plotted against the horizontal position of the center of gravity in figure 23. The tailed symbols are the one-half cycle amplitudes referred to in the preceding paragraph. At forward positions of the center of gravity and neutral elevators, less than 2° amplitude of porpoising was observed. With elevator deflections no greater than -10°, stable take-offs were possible at all positions of the center of gravity tested forward of 31 percent mean aerodynamic chord. The location of the main step is therefore believed to be satisfactory.

The maximum amplitude of porpoising for models 192A-1 and 192B-1 is plotted against the horizontal position of the center of gravity in figures 24 and 25, respectively. At forward positions of the center of gravity and with neutral elevators, slight porpoising at high speed was encountered for models 192A-1 and 192B-1; but this amplitude of porpoising was not included in the summary curves because, at these high speeds, the trims were lower than those generally used for take-off. A comparison of the variation of maximum amplitude of porpoising with position of the center of gravity for models 192, 192A-1, and 192B-1 is presented in figure 26.

With neutral elevators and forward positions of the center of gravity the behavior of the three models was approximately the same. With -10° elevators, the after limit for stable positions of the center of gravity was moved aft approximately 7 percent of the mean aerodynamic chord when the depth of step was increased (compare models 192 and 192A-1), but was not moved any farther aft when the angle of afterbody keel was increased (compare models 192A-1 and 192B-1). With -25° elevators, the change in the after limit for the three models was in the same direction, but was less apparent than that obtained with -10° elevators.

Landing stability.- Records of the variation of trim and draft during landings of models 192, 192A-1, 192B, and 192B-1 are shown in figures 27 to 30. A comparison of the landing characteristics of models tested in the tank is usually made by counting the number of skips (number of times main step leaves the water) during landings. This comparison is given for models 192, 192A-1, 192B, and 192B-1 in the following table:

Model no.	Center of gravity, percent M.A.C.	Power	Gross load, Δ_o, lb	Landing trim, deg	No. of skips	Figure no.
192	34	Zero	60.1	4.2 5.5 7.1 9.2 11.5	0 0 8 6 7	27(a)
	34		71.7	5.1 6.1 6.9 8.8 10.6	0 0 11 8 7	27(b)
	24		60.1	5.3 7.0 9.0	0 8 6	27(c)
	24	Half	60.1	6.3 8.0 8.5	0 5 5	27(d)

Model no.	Center of gravity, percent M.A.C.	Power	Gross load, Δ_0, lb	Landing trim, deg	No. of skips	Figure no.
192A-1	34	Zero	60.1	5.4	0	28(a)
				7.6	0	
				10.4	0	
				11.4	0	
				17.0	0	
	34		71.7	5.6	0	28(b)
				6.4	0	
				8.8	0	
				10.7	0	
				16.0	3	
	24		60.1	4.0	0	28(c)
				6.0	0	
				6.7	0	
				8.6	0	
				9.0	0	
192B	34	Zero	60.1	4.0	0	29
				5.5	8	
				7.0	7	
				8.7	6	
				10.0	5	
				11.8	4	
192B-1	34	Zero	60.1	6.4	0	30
				8.3	0	
				10.2	0	
				11.0	4	
				11.9	5	
				15.6	4	

In general violent skipping occurred at trims greater than 6° for model 192. This skipping was attributed to the shallow main step. A decrease in the gross load or an application of power tended to reduce the landing instability. Landing instability could be reduced in some cases by use of the elevators to decrease the trim of the model at the instant of contact with the water.

With the depth of the step of the basic model increased from 3.8 to 7.0 percent beam (model 192A-1) stable landings were made at all trims up to 16° (fig. 28). With the angle of afterbody keel increased from 6.25° to 7.75° and with the shallow step (model 192B) the model skipped violently at trims above 5° (fig. 29). With the depth of step of model 192B increased from 3.8 to 7.0 percent beam (model 192B-1) the model skipped violently at trims above 11° (fig. 30).

The results of the landing tests indicate that, with the deep step (7 percent beam) in conjunction with an angle of afterbody keel of 6.25°, the model was stable on landing. However, the same depth of step was not adequate for landing stability at high trims for the model with the higher angle of afterbody keel (7.75°). If the landing stability at the two angles of afterbody keel is compared, it can be seen that the increase in angle of afterbody keel tended to reduce the landing stability at both depths of step.

CONCLUSIONS

1. Spray strips around the bow reduced the spray over the bow at low speeds. An increase in depth of step or angle of afterbody keel, which increased the trim at low speeds, reduced slightly the spray over the bow.

2. Spray strips around the bow reduced the range of speeds over which spray entered the propellers. This range was not affected by an increase in angle of afterbody keel. An increase in depth of step (by lowering the forebody), which increased the propeller clearance, reduced the range of speeds over which the spray entered the propellers.

3. With a depth of step of 3.8 percent beam (at the centroid) the basic model was unstable in landing for trims above 6°. This landing instability was eliminated by an increase in depth of step to 7 percent beam. An increase in angle of afterbody keel tended to decrease landing stability.

4. The location of the main step was satisfactory for take-off with neutral or up elevators at forward positions of the center of gravity, and with elevator deflections of -10° or less at after positions of the center of gravity.

5. With neutral elevators, an increase in depth of step or angle of afterbody keel had no appreciable effect on the forward limit for stable positions of the center of gravity. With -10° elevators, an increase in depth of step moved the after limit for stable positions of the center of gravity farther aft. An increase in angle of afterbody keel had no further effect on this limit.

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National Advisory Committee for Aeronautics
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1. Truscott, Starr: The Enlarged NACA Tank, and Some of Its Work. NACA TM No. 918, 1939.

2. Olson, Roland E., and Land, Norman S.: The Longitudinal Stability of Flying Boats as Determined by Tests of Models in the NACA Tank. I - Methods Used for the Investigation of Longitudinal-Stability Characteristics. NACA ARR, Nov. 1942.

TABLE I - MODEL PARTICULARS OF PBN-1

Item	Model 192, 1/8-size
Hull:	
Beam, maximum, in.	15.30
Length of forebody (bow to centroid of main step), in.	38.67
Length of afterbody (centroid of main step to second step), in.	31.46
Length of tail extension, in.	27.50
Length, over-all, in.	97.63
Plan form of step	20° vee
Depth of step, at keel, in.	0.59
Depth of step, at centroid of vee, in.	0.40
Angle of dead rise at step,	
Excluding chine flare, deg	22.5
Including chine flare, deg	19.0
Angle of forebody keel, deg.	1.05
Angle of afterbody keel, deg	6.25
Angle between keel lines at step, deg.	7.30
Wing:	
Area, sq ft	21.9
Span, in.	156.0
Root chord, in.	22.5
Tip chord, in.	15.0
Angle of incidence, deg	6.0
Mean aerodynamic chord (M.A.C.)	
Length, in.	20.76
Leading edge aft of bow, in.	27.6
Leading edge forward of point of step, in.	12.7
Leading edge above base line, in.	6.0
Angle to base line, deg	18.6
Horizontal tail surface:	
Area, sq ft	3.2
Span, in.	45.8
Angle of stabilizer to wing chord, deg	-2.0
Angle of dihedral, deg	0.0
Elevator chord, in.	6.8
Elevator span, one side, in.	14.3
Elevator root section	NACA M-2

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TABLE I - MODEL PARTICULARS OF PBN-1 - Concluded

Item	Model 192, 1/8-size
Propellers:	
Number of propellers	2
Number of blades	3
Diameter, in.	18
Angle of thrust line to base line, deg	0
Angle of blade at 0.75 radius, deg	17

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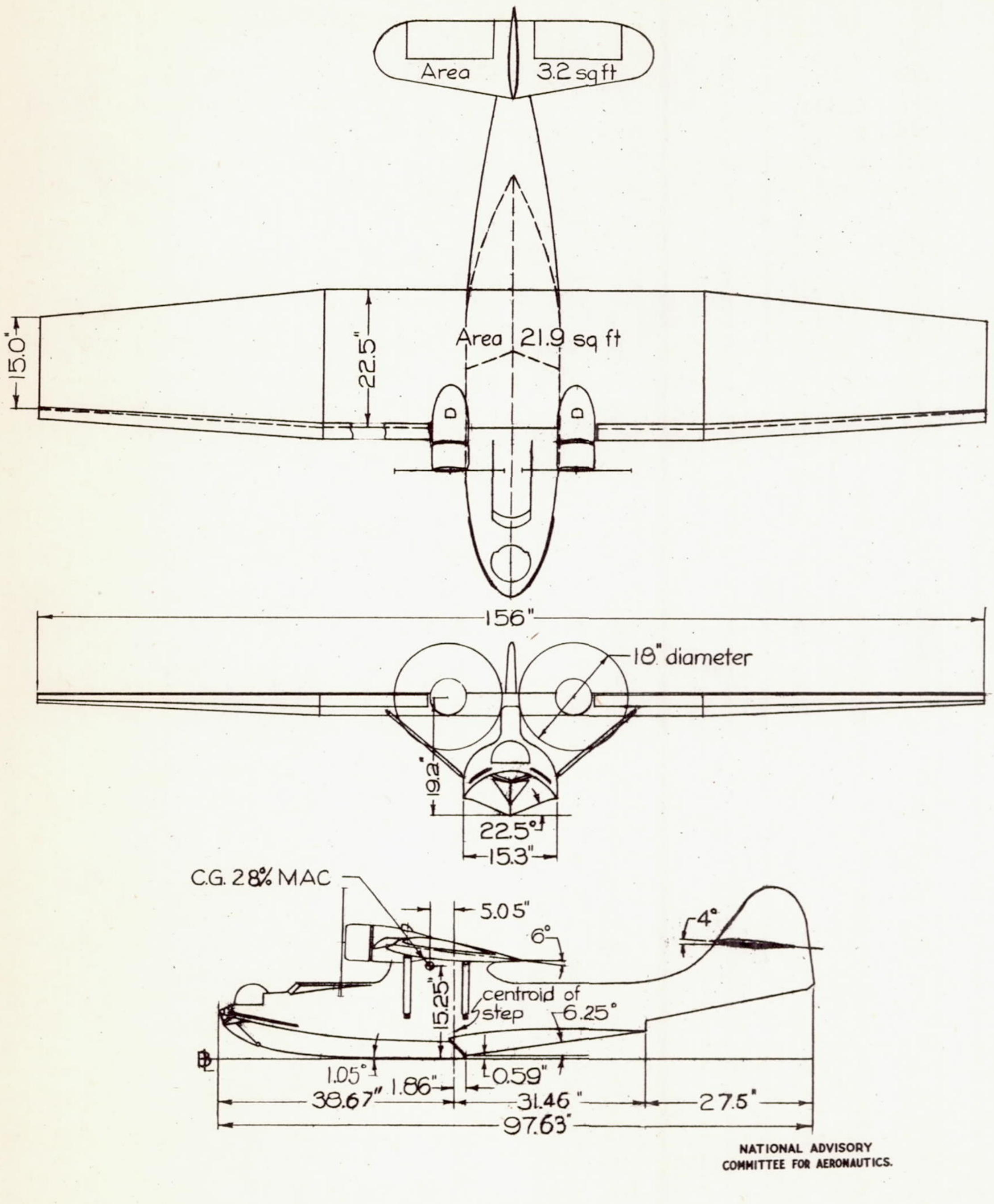

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Figure 1.– Model 192. General arrangement.

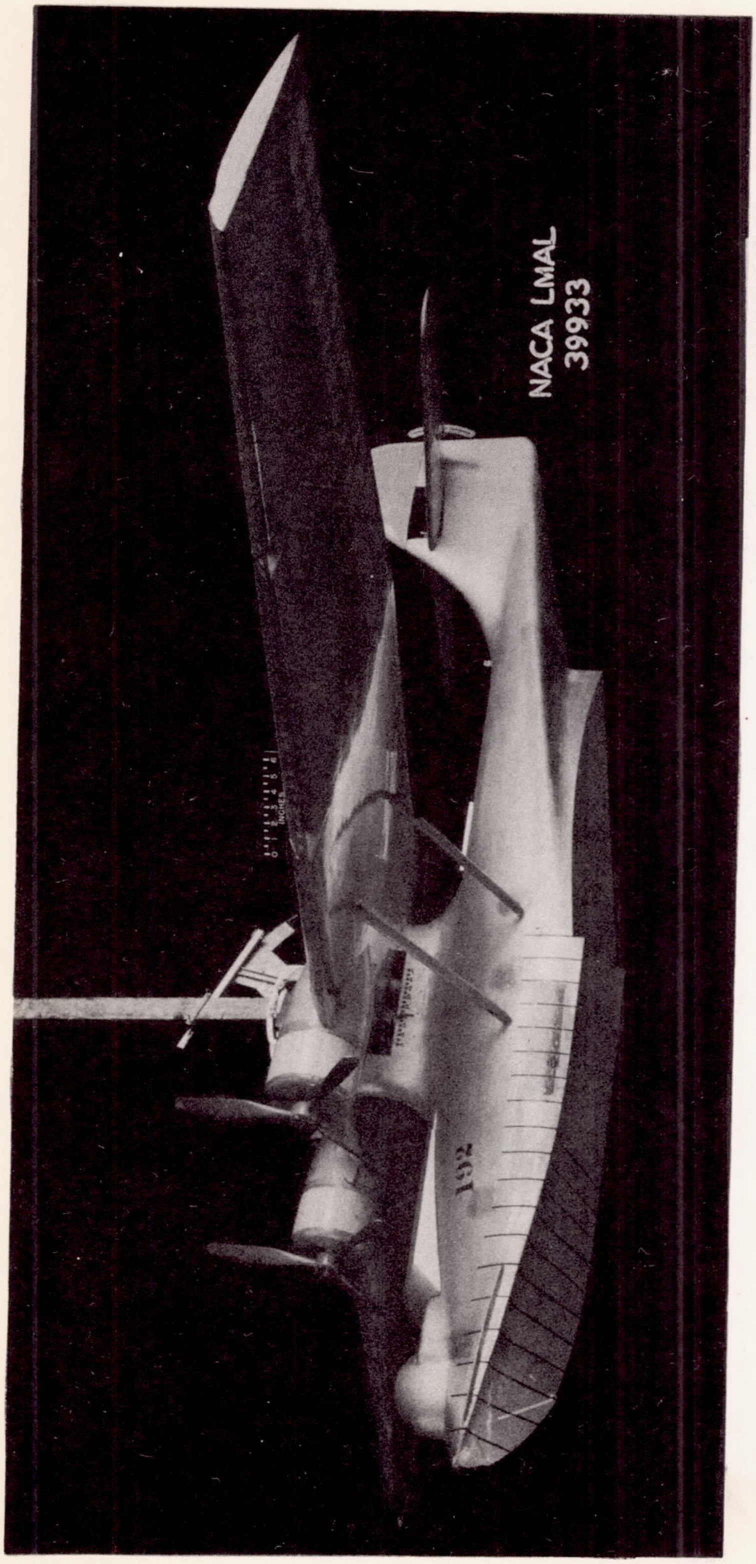
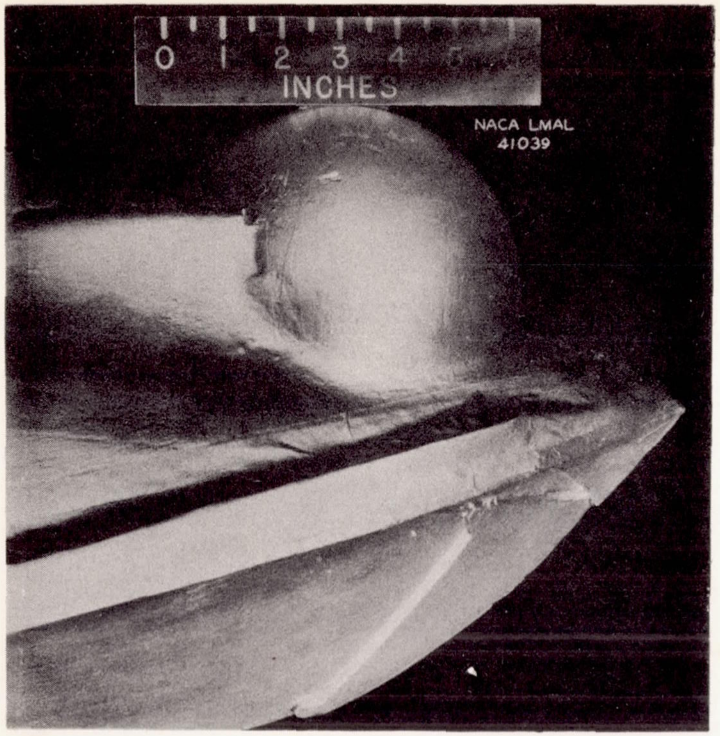
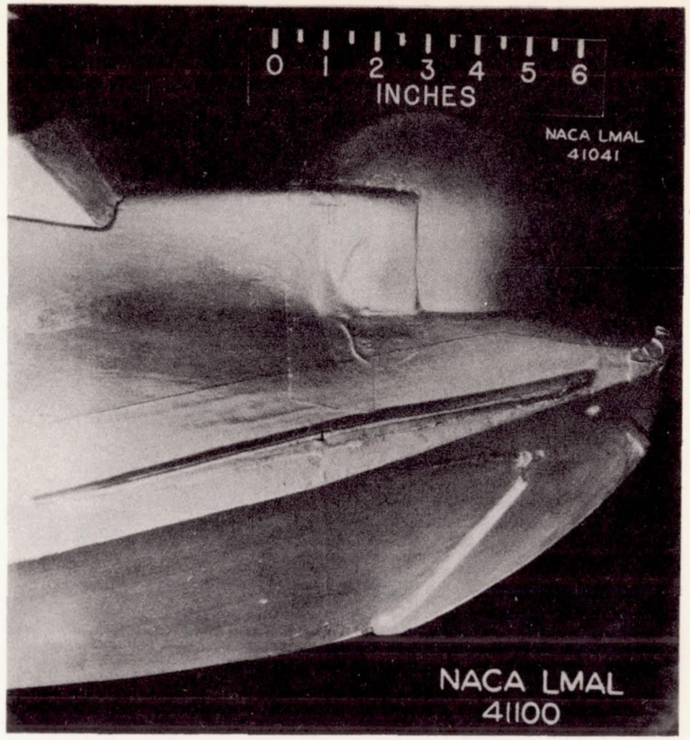


Figure 2.- Photograph of basic model 192.



Model 192A.



Model 192

Figure 3a.- Photographs of bows for models 192 and 192A.

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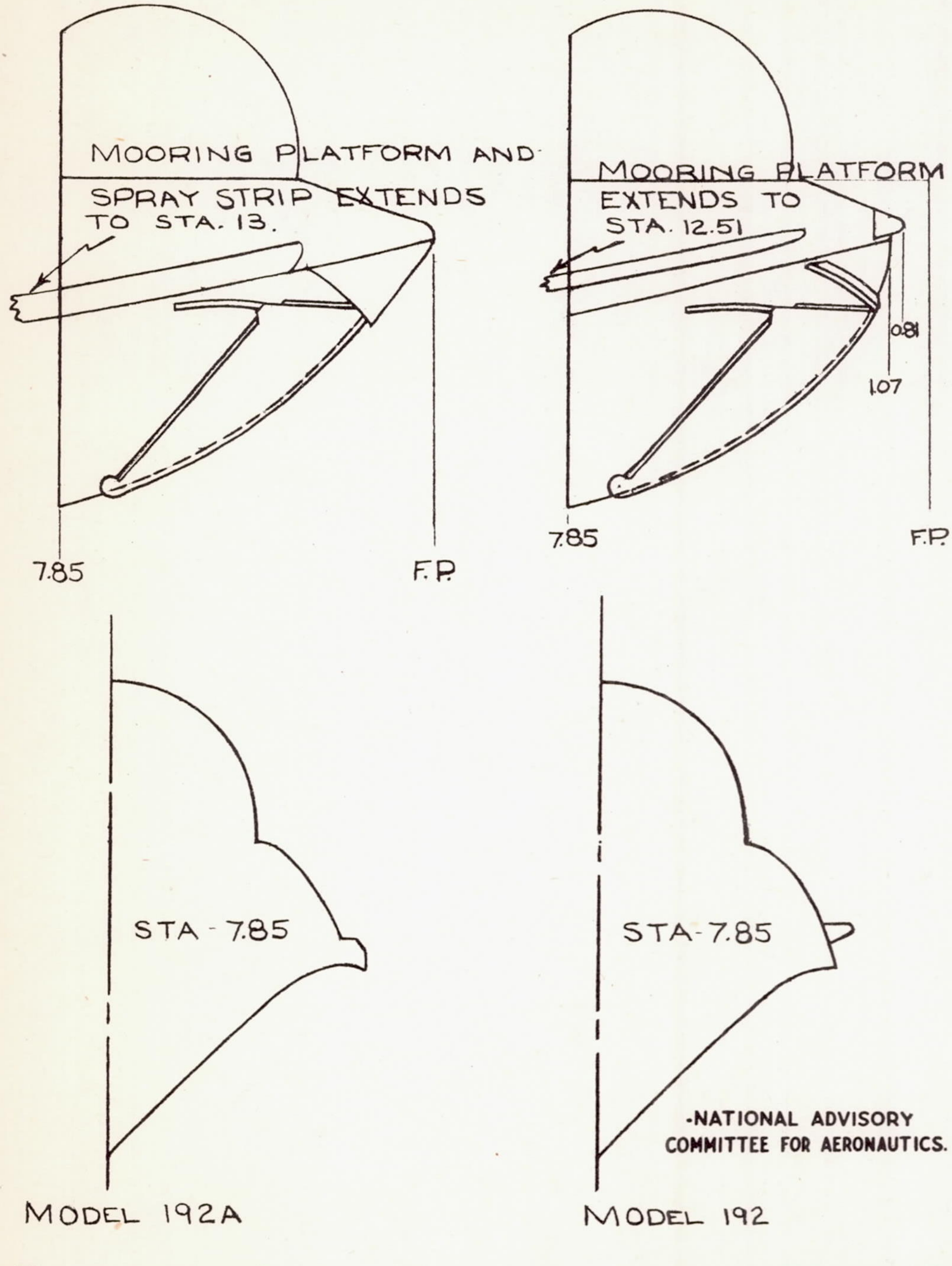

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Figure 3(b).- Sketch of bows for models 192 and 192A.

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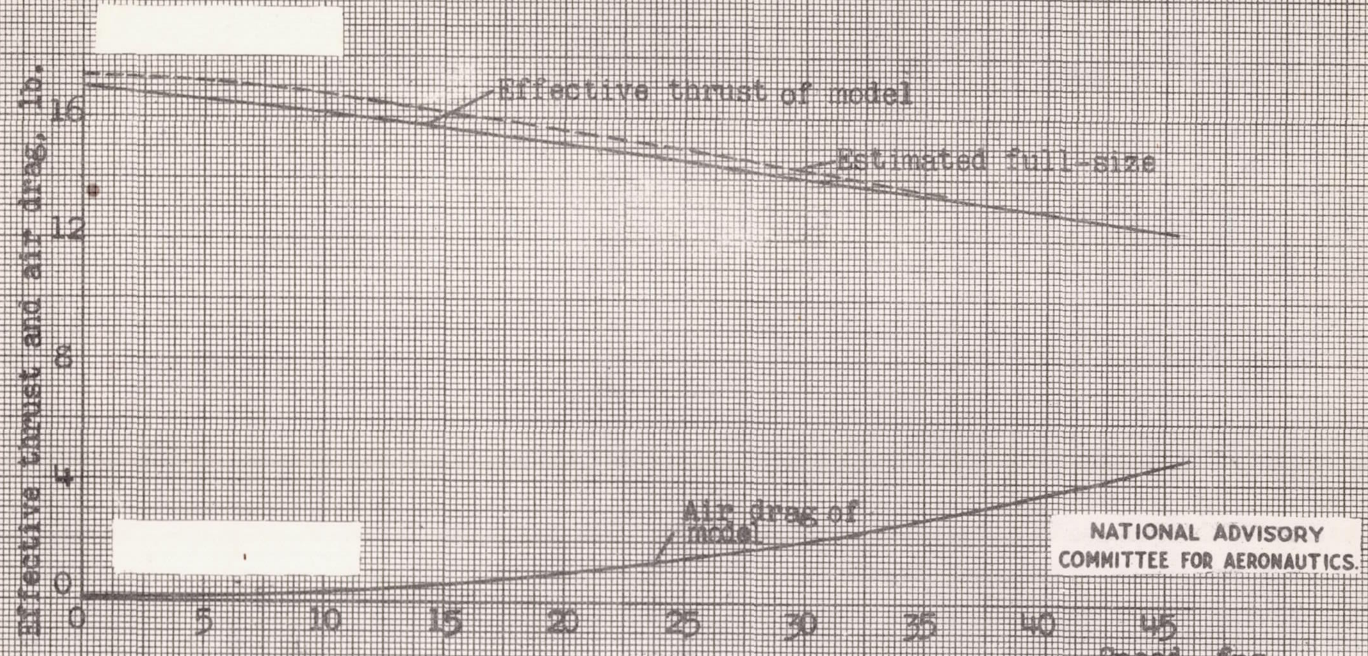

Figure 4.- Model 192. Variation of effective thrust and air drag with speed. Trim, 0°; δ_s, -2° to wing chord; δ_e, 0°.

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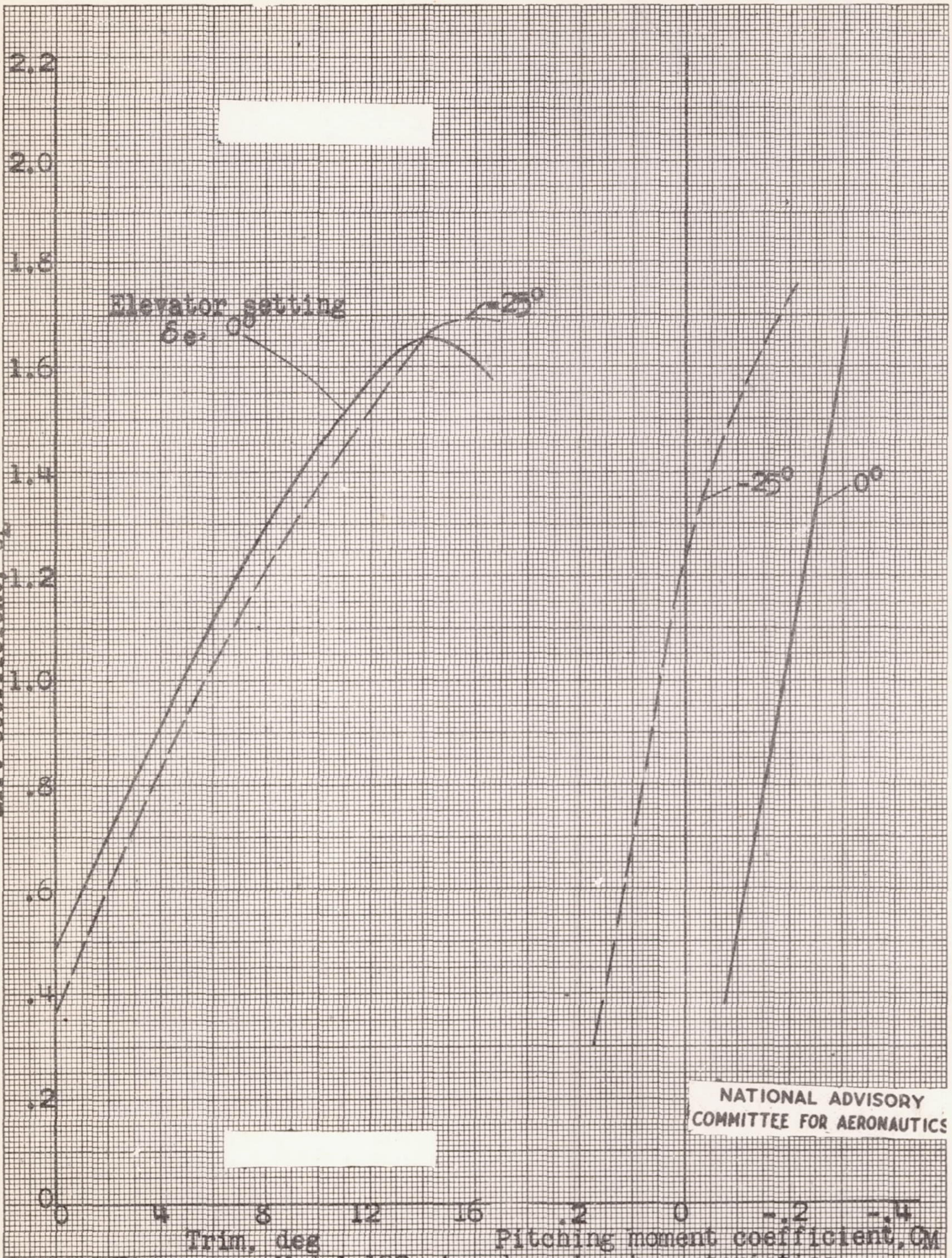

Figure 5.- Model 192. Aerodynamic characteristics without power. Speed 45 fps; δ_s, -2° to wing chord.

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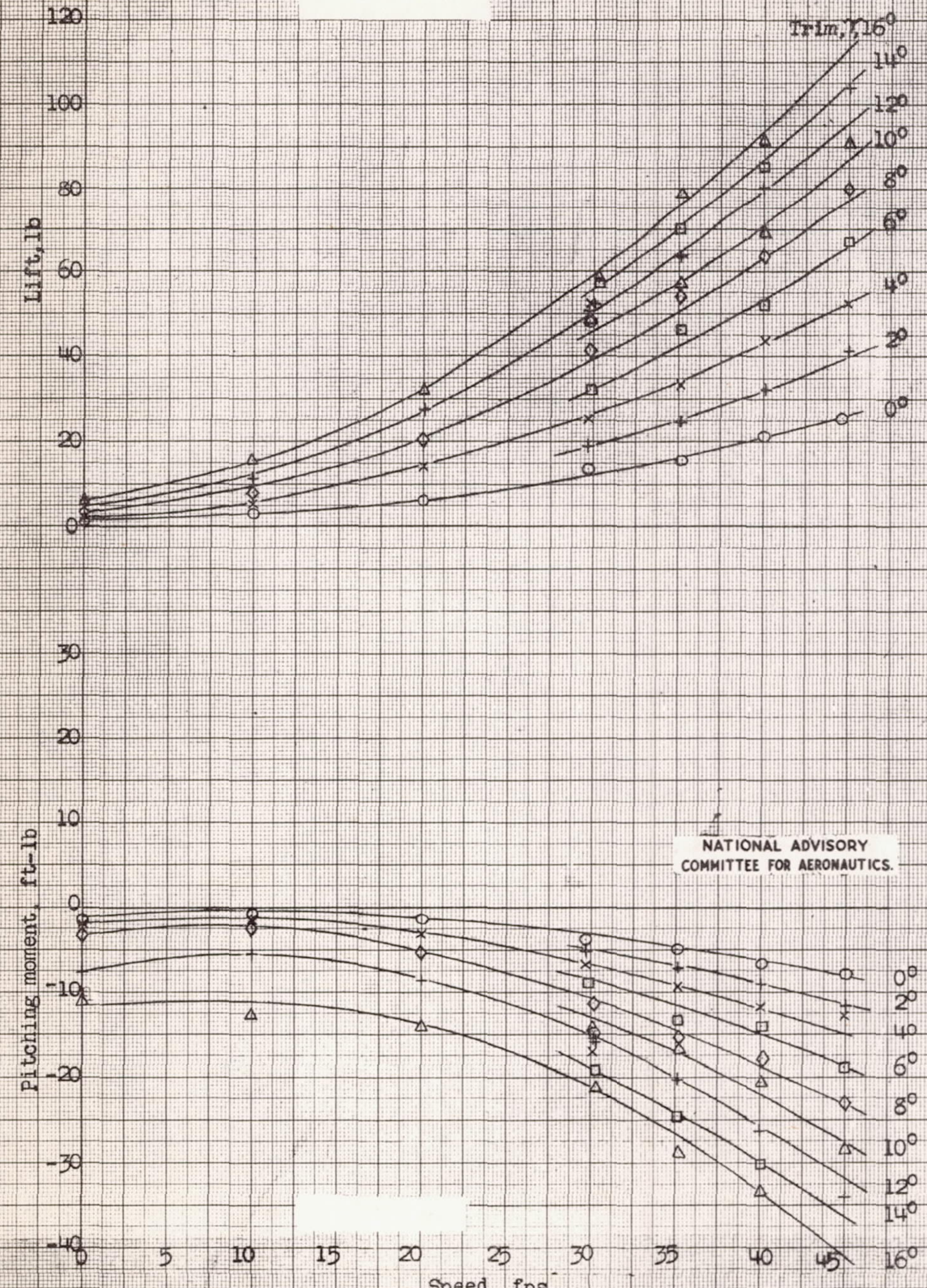

(a). δ_e, 0°

Figure 6.- Model 192. Variation of lift and pitching moment with speed. Power, 4335 rpm; δ_s, -2° to wing chord.

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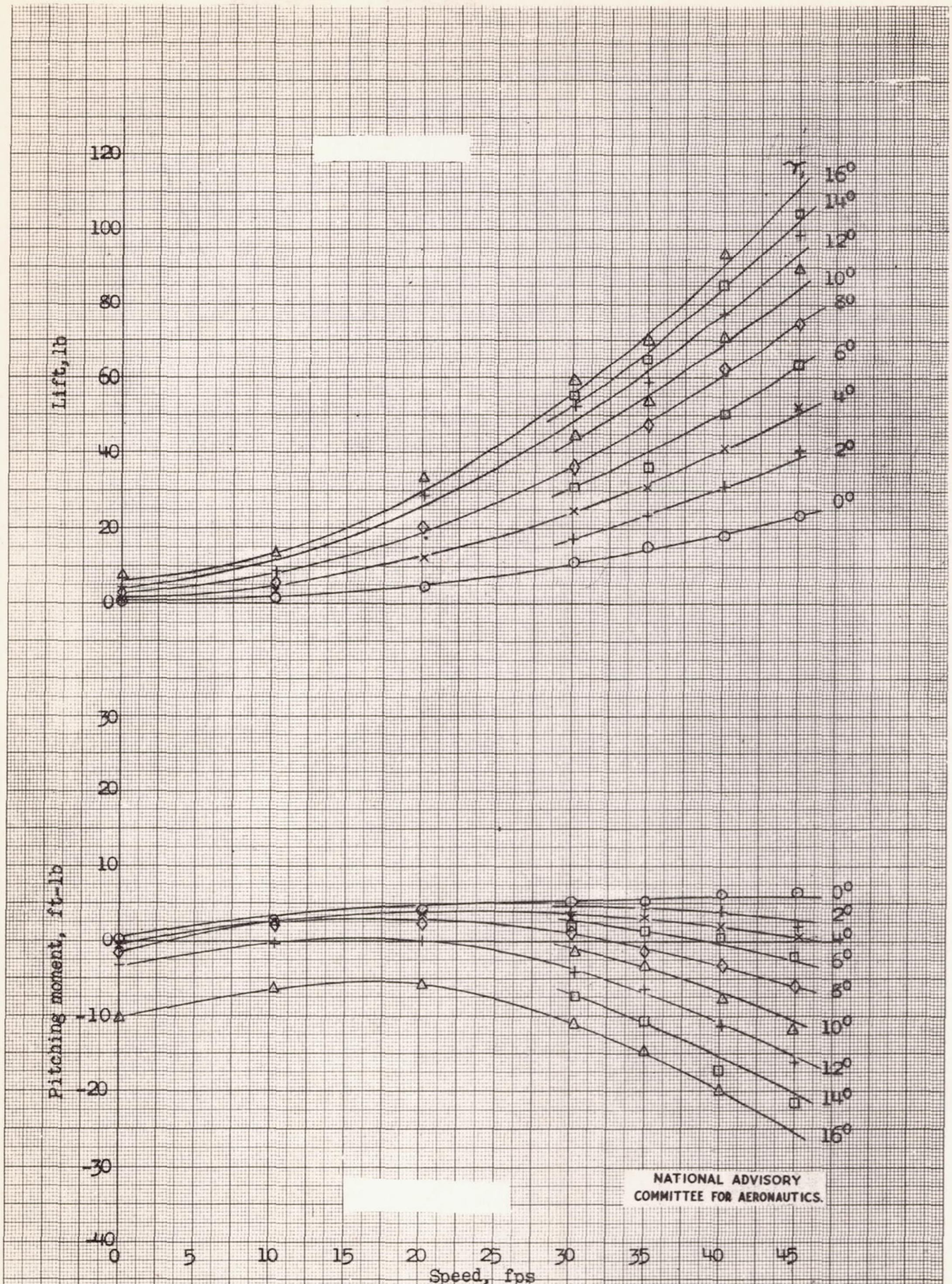
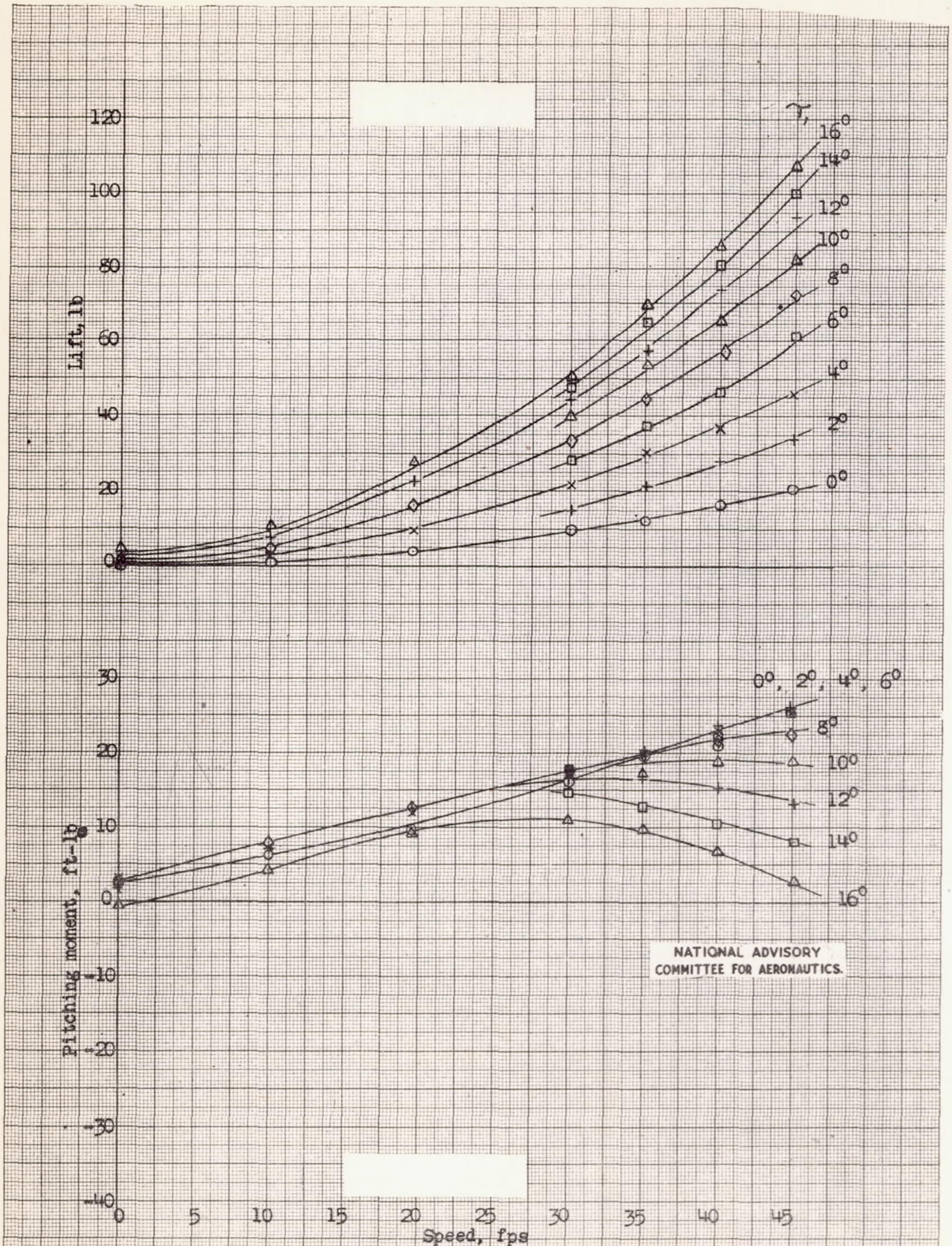


(b). δ_e, -10°

Figure 6.- Model 192.- Continued.



(c). δ_e, -25°

Figure 6.- Model 192.- Concluded.

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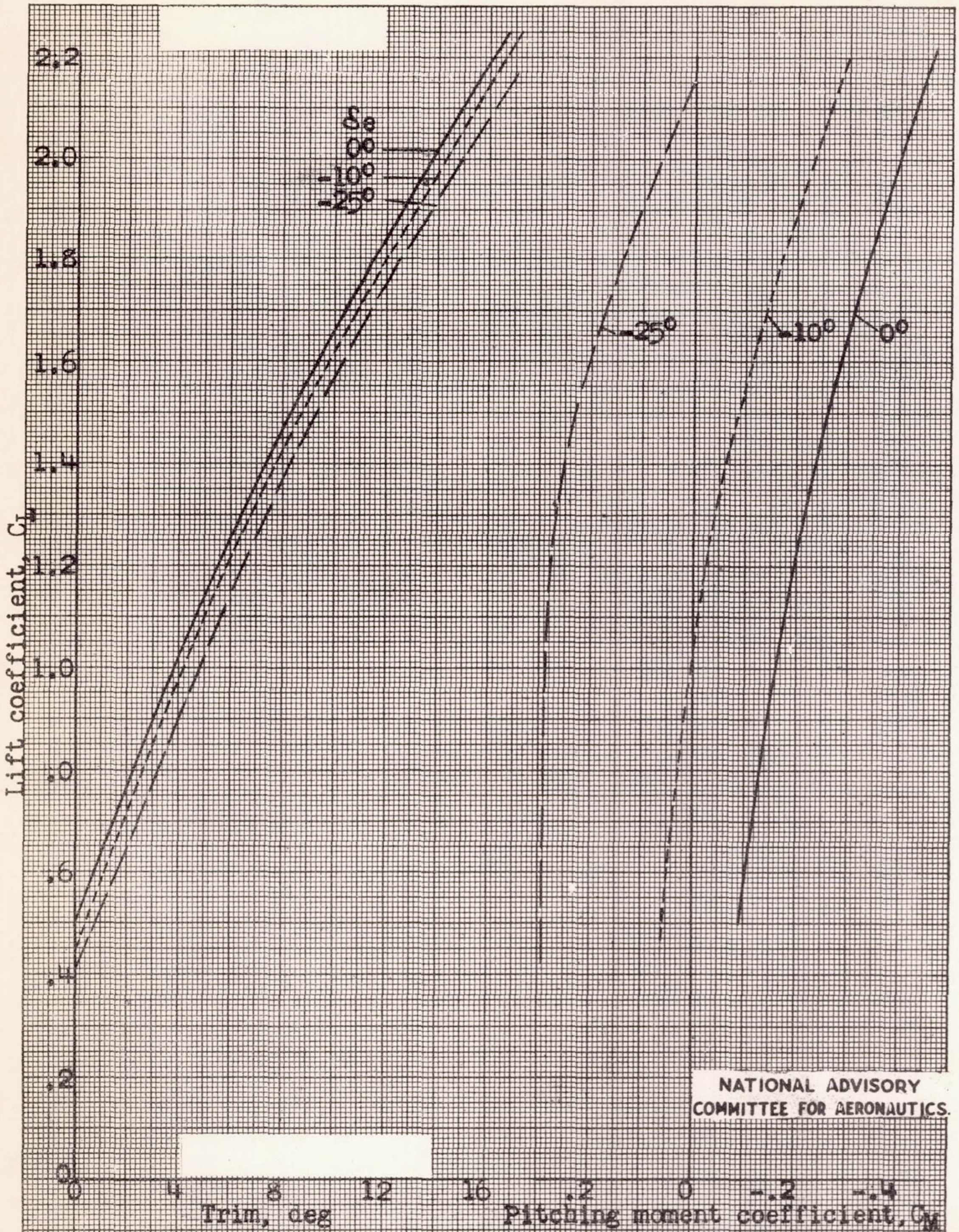

Figure 7.- Model 192. Aerodynamic characteristics with power (4335 rpm). Speed 45 fps; δ_s, -2° to wing chord.

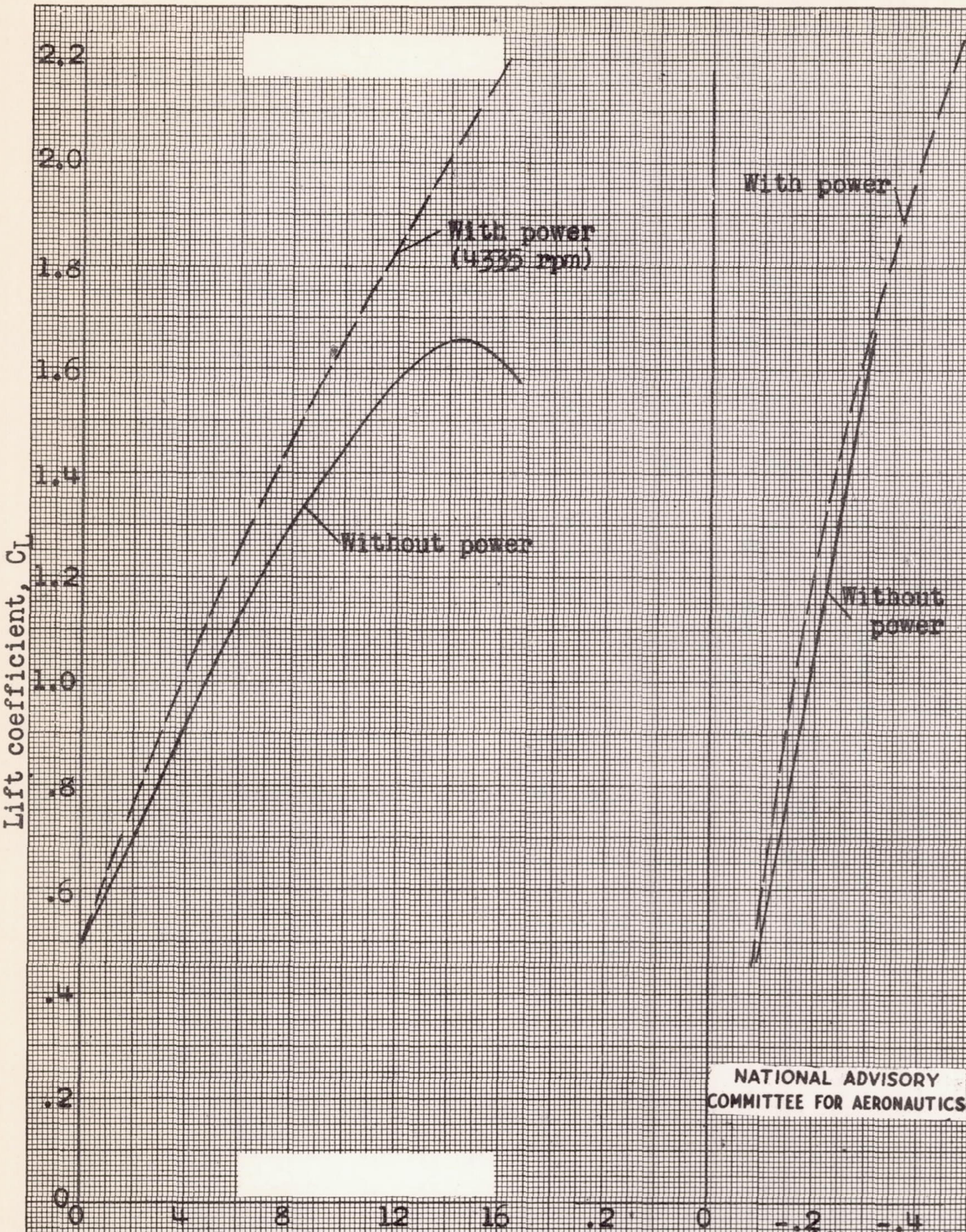

Figure 8.- Model 192. Comparison of aerodynamic characteristics with and without power. Speed 45 fps; δ_e, 0°; δ_s, -2° to wing chord.

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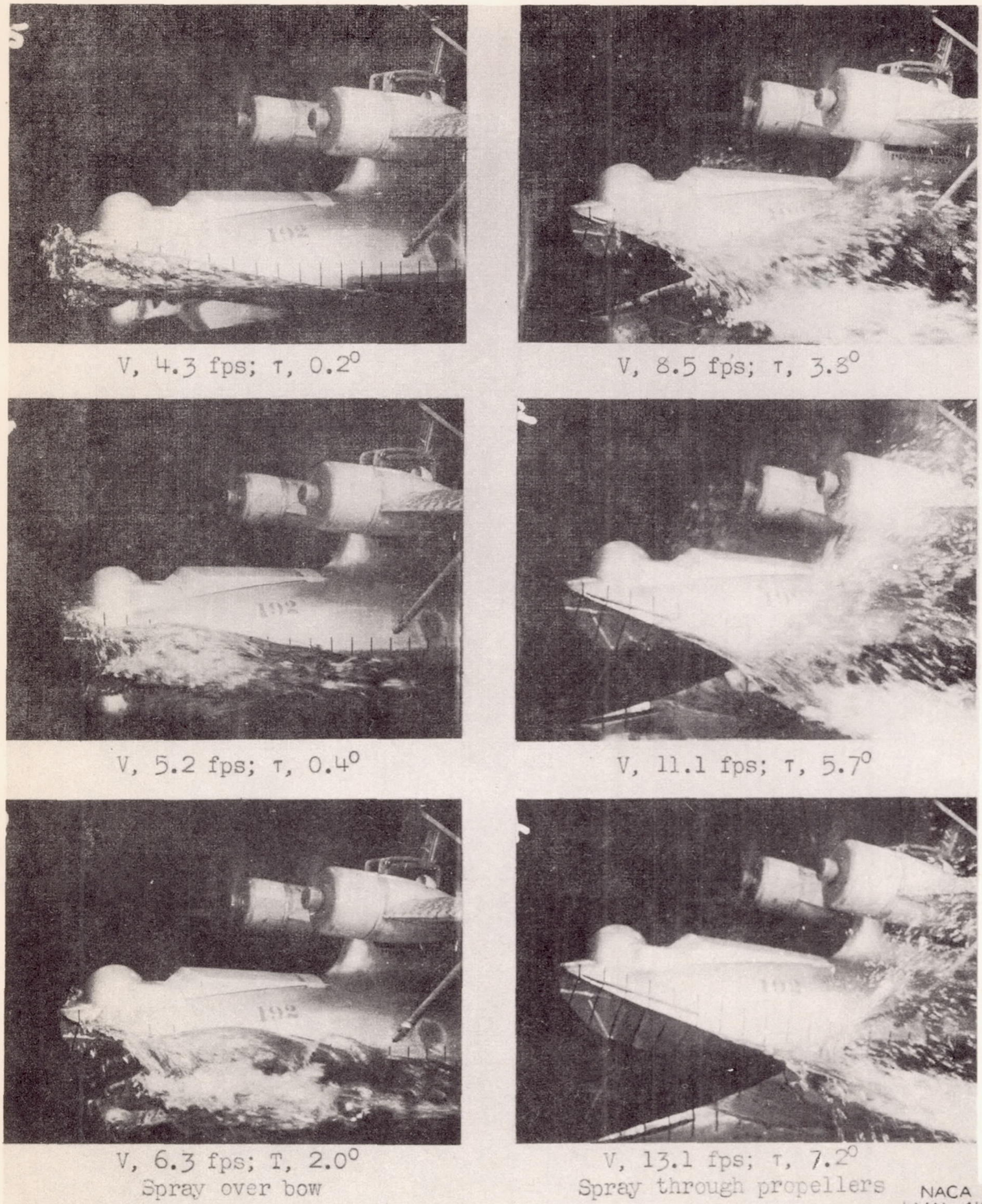

V, 4.3 fps; τ, 0.2°

V, 8.5 fps; τ, 3.8°

V, 5.2 fps; τ, 0.4°

V, 11.1 fps; τ, 5.7°

V, 6.3 fps; τ, 2.0°
Spray over bow

V, 13.1 fps; τ, 7.2°
Spray through propellers

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LMAL 41241

Figure 9.- Model 192. Spray characteristics at low taxiing speed; with power (4335 rpm). Δ_o, 71.7 pounds (37,000 pounds full-size); center of gravity, 28 percent mean aerodynamic chord.

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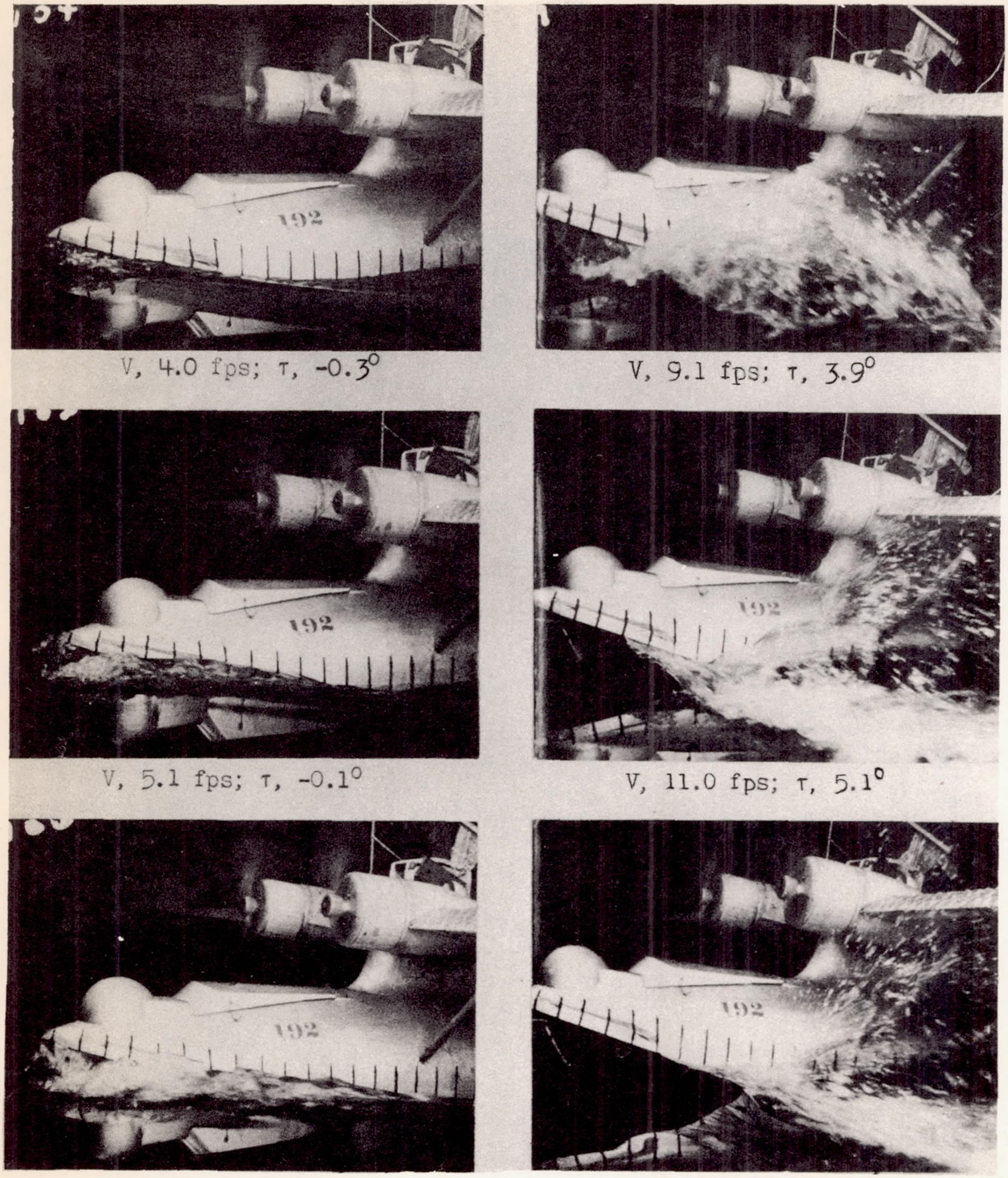

V, 4.0 fps; τ, -0.3°

V, 9.1 fps; τ, 3.9°

V, 5.1 fps; τ, -0.1°

V, 11.0 fps; τ, 5.1°

V, 6.2 fps; τ, 1.7°
Spray over bow

V, 13.0 fps; τ, 7.2°
Spray through propellers

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LMAL 41242

Figure 10.- Model 192A. Spray characteristics at low taxiing speed; with power (4335 rpm). Δ_0, 71.7 pounds (37,000 pounds full-size); center of gravity, 28 percent mean aerodynamic chord.

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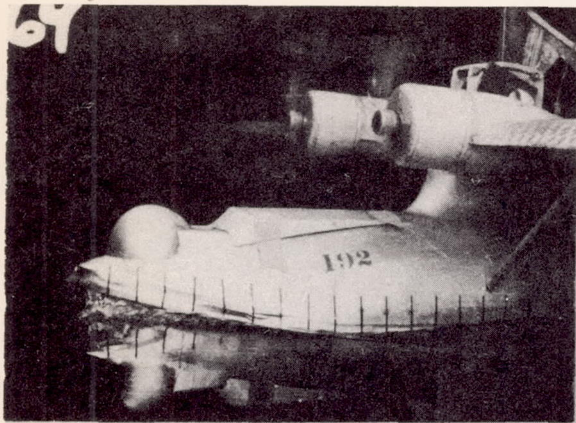
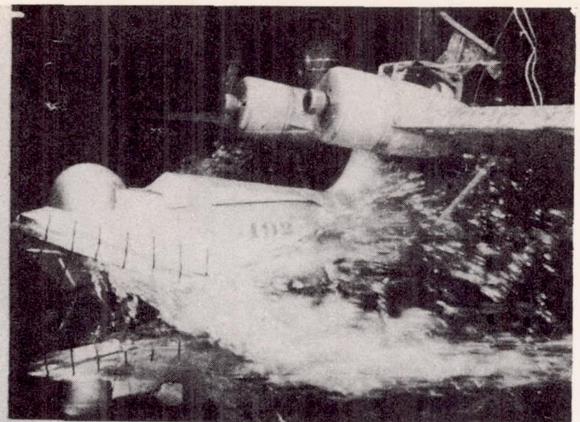
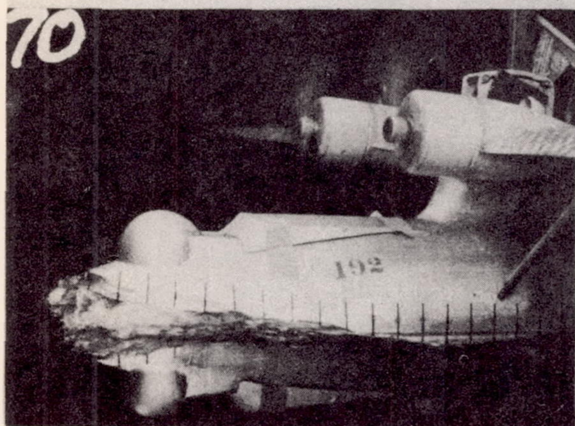


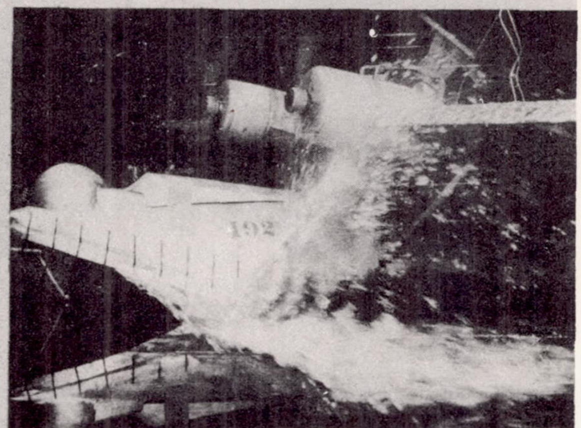
V, 4.0 fps; τ, 0.6°



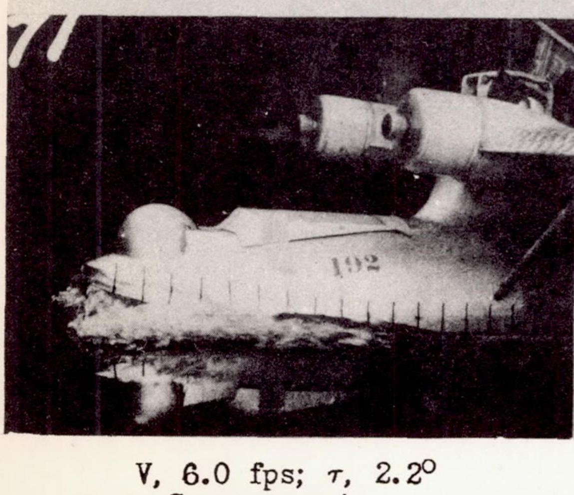
V, 9.8 fps; τ, 5.1°



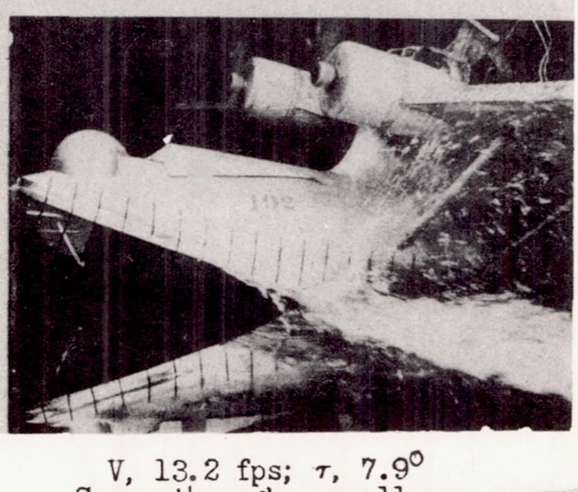
V, 4.9 fps; τ, 0.7°



V, 11.0 fps; τ, 6.0°

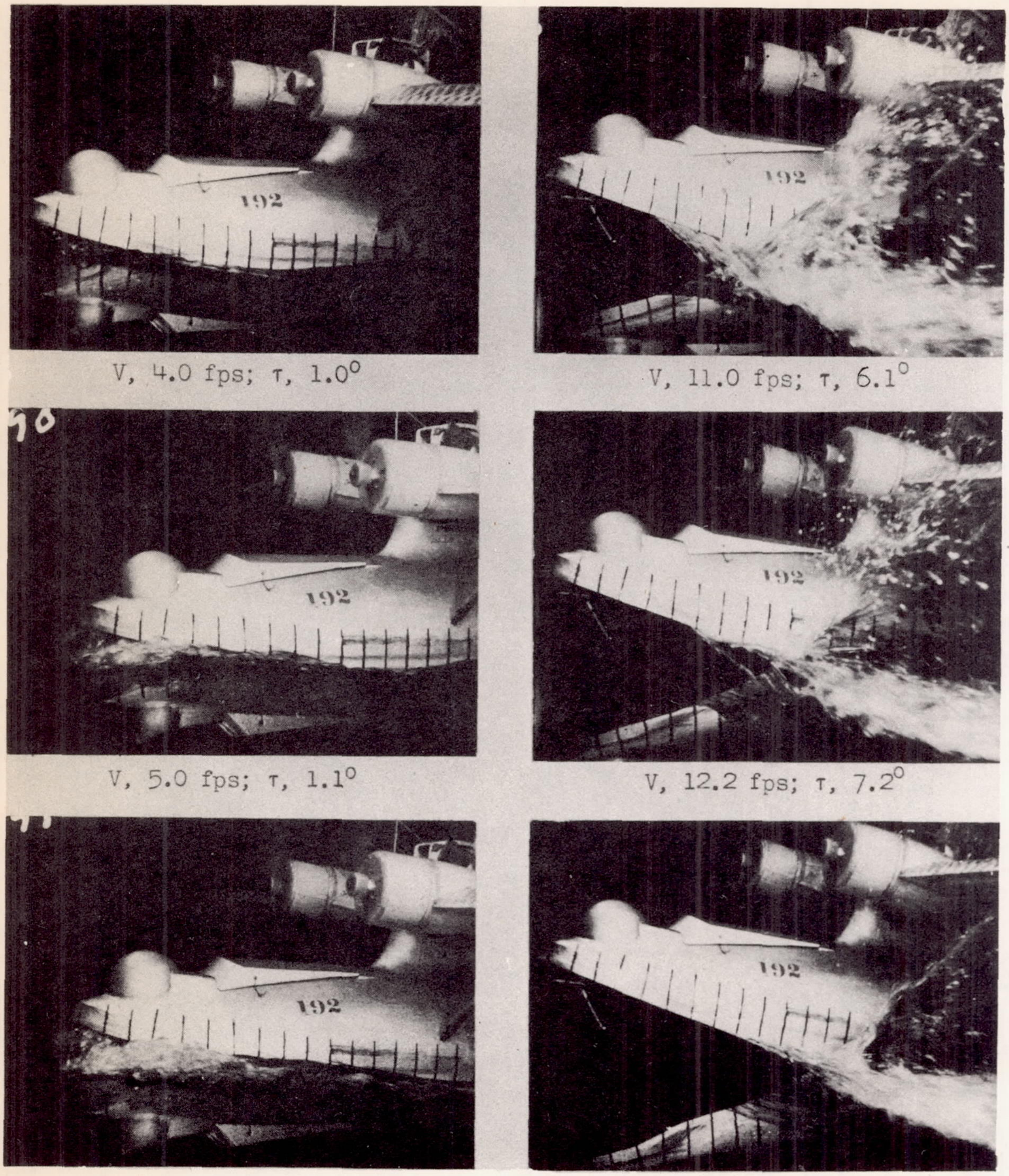


V, 6.0 fps; τ, 2.2°
Spray over bow



V, 13.2 fps; τ, 7.9°
Spray through propellers

Figure 11.- Model 192A-1. Spray characteristics at low taxiing speed; with power (4335 rpm). Δ_0, 71.7 pounds (37,000 pounds full-size); center of gravity, 28 percent mean aerodynamic chord.



V, 4.0 fps; τ, 1.0°

V, 11.0 fps; τ, 6.1°

V, 5.0 fps; τ, 1.1°

V, 12.2 fps; τ, 7.2°

V, 6.0 fps; τ, 2.5°
Spray over bow

V, 13.2 fps; τ, 8.3°
Spray through propellers

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Figure 12.- Model 192A-2. Spray characteristics at low taxiing speed; with power (4335 rpm). Δ_0, 71.7 pounds (37,000 pounds full-size); center of gravity, 28 percent mean aerodynamic chord.

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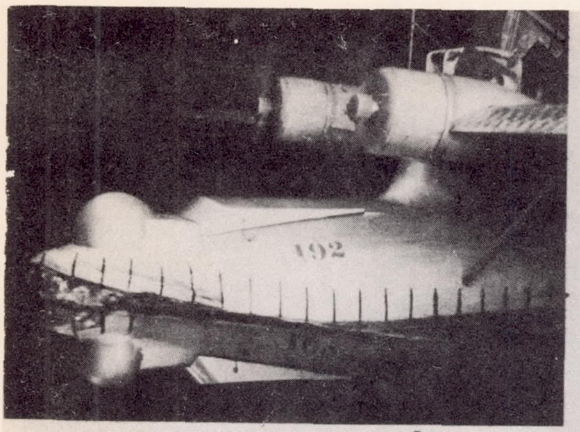
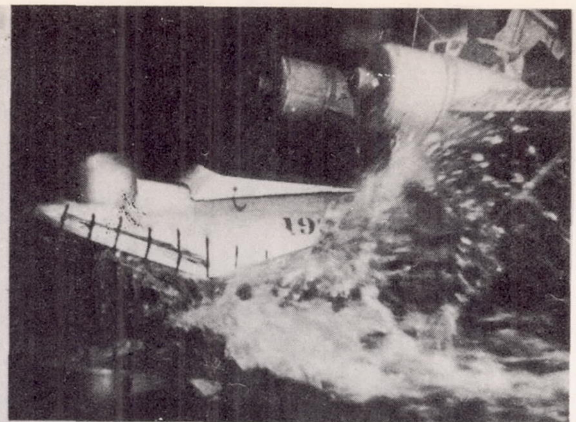
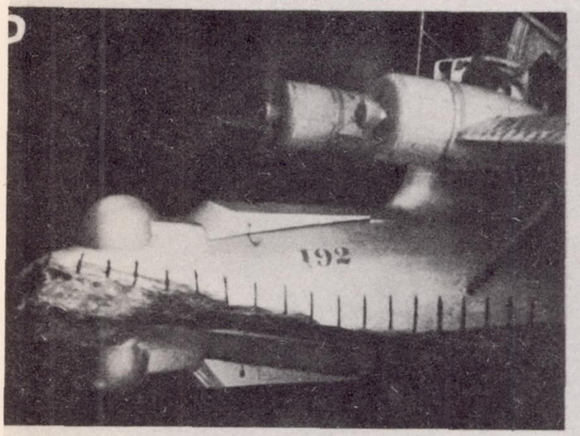


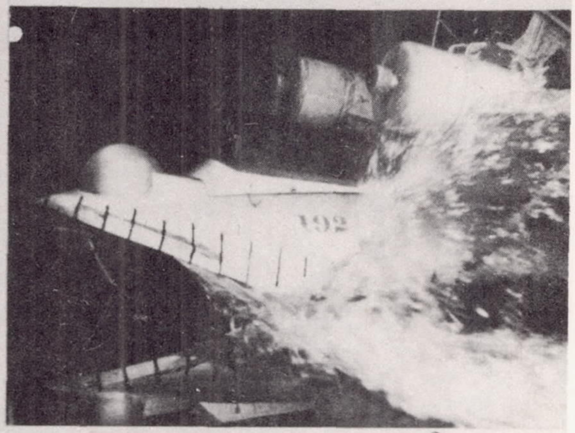
V, 4.1 fps; τ, 0.1°



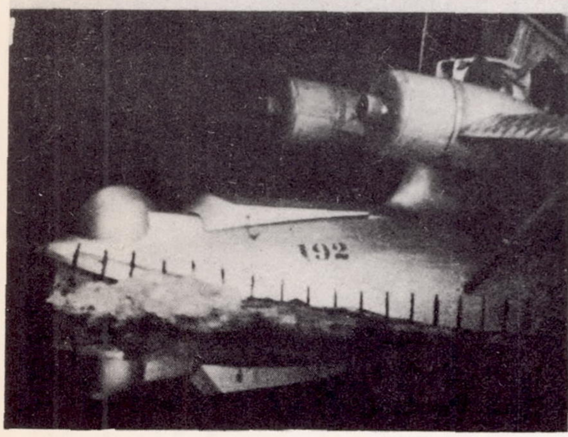
V, 9.2 fps; τ, 5.0°



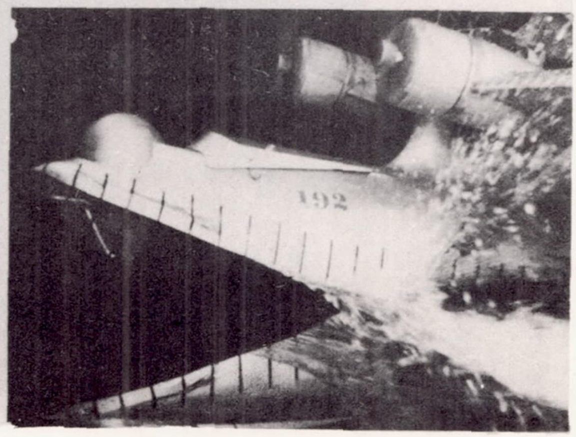
V, 5.1 fps; τ, 0.8°



V, 11.1 fps; τ, 6.0°



V, 6.0 fps; τ, 2.1°
Spray over bow



V, 12.8 fps; τ, 7.0°
Spray through propellers

NACA
LMAL 41245

Figure 13.- Model 192B. Spray characteristics at low taxiing speed; with power (4335 rpm). Δ_0, 71.7 pounds (37,000 pounds full-size); center of gravity, 28 percent mean aerodyanmic chord.

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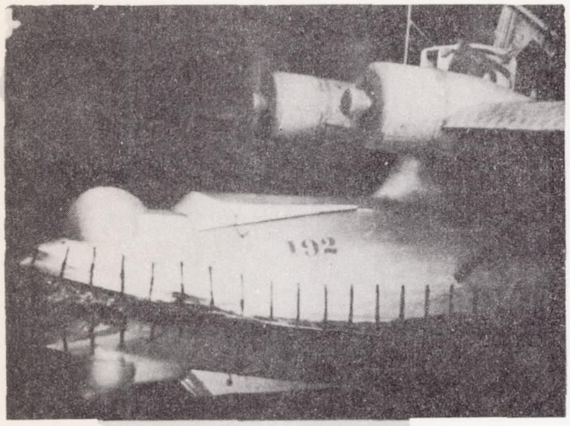
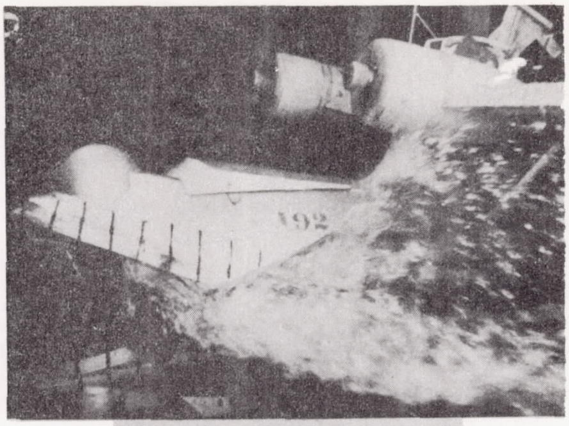
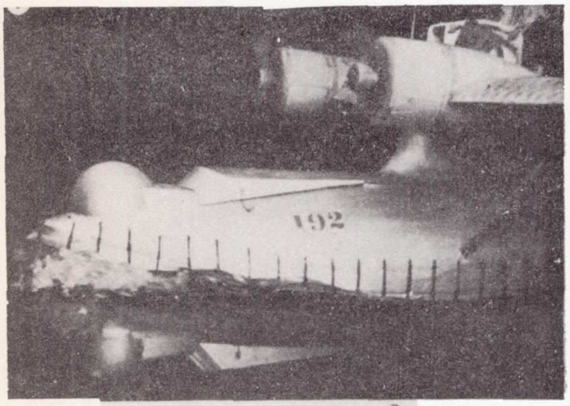


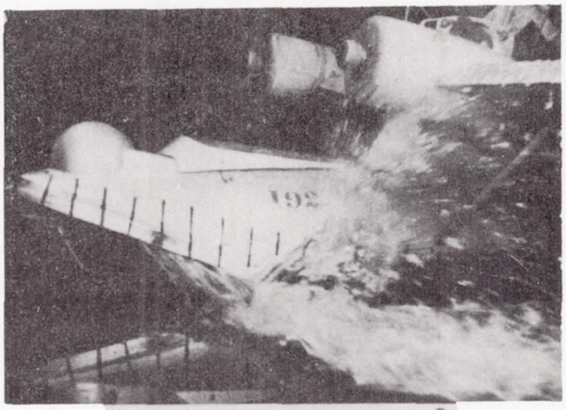
V, 4.1 fps; τ, 0.8°



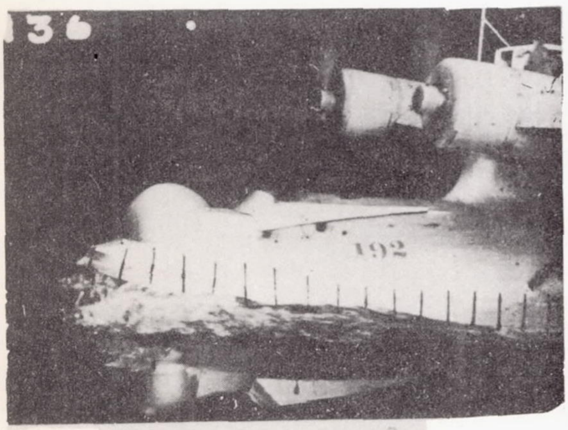
V, 10.0 fps; τ, 5.8°



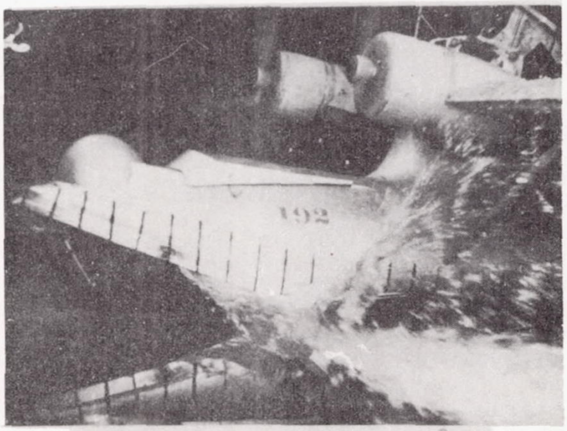
V, 4.9 fps; τ, 0.8°



V, 11.0 fps; τ, 6.2°



V, 5.9 fps; τ, 2.1°
Spray over bow



V, 12.0 fps; τ, 7.1°
Spray through propellers

NACA
LMAL 41246

Figure 14.- Model 192B-1. Spray characteristics at low taxiing speed; with power (4335 rpm). Δ_0, 71.7 pounds (37,000 pounds full-size); center of gravity, 28 percent mean aerodynamic chord.

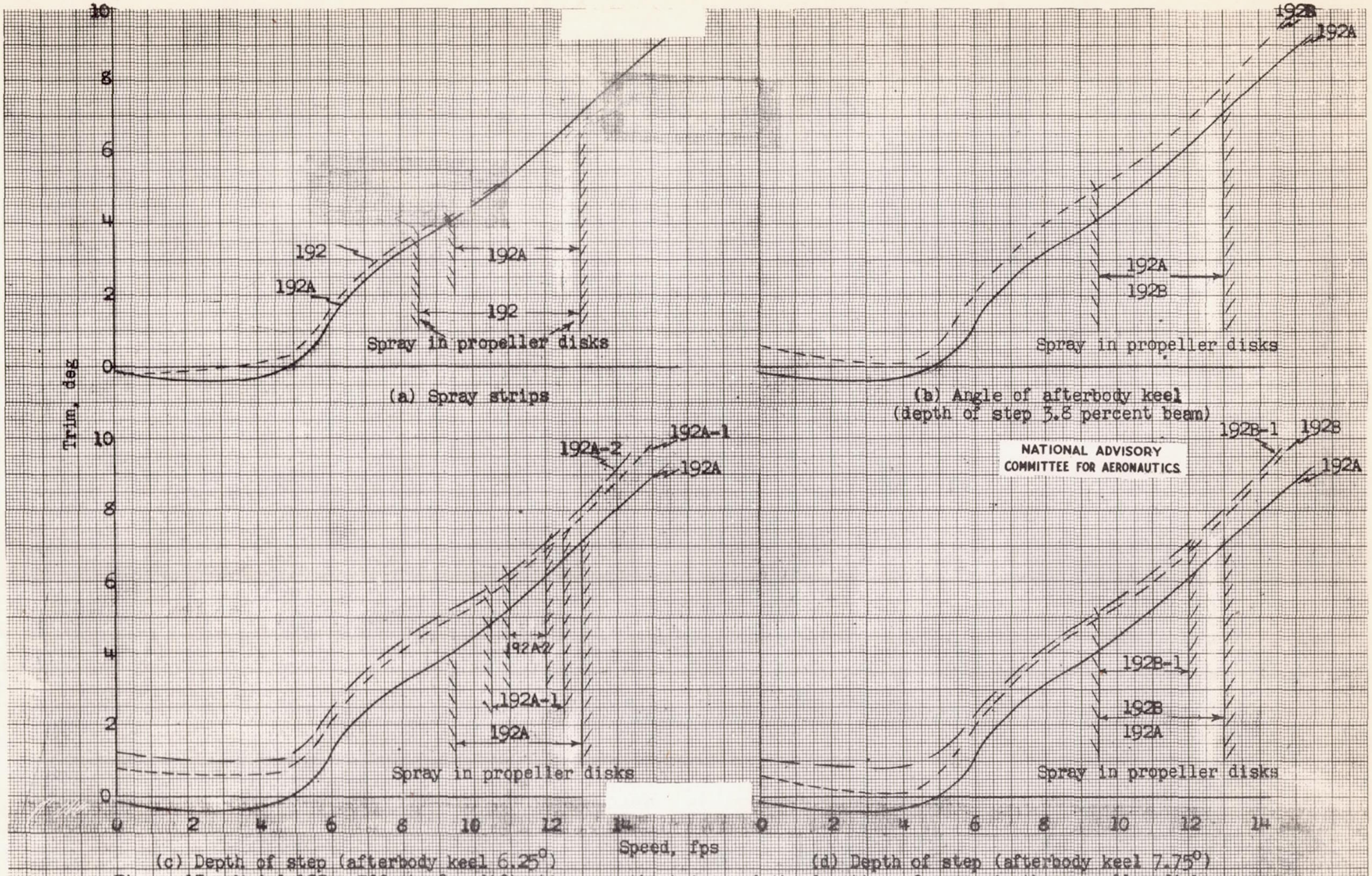


Figure 15.- Model 192. Effect of modifications on the trim, and the duration of spray in the propeller disks; with power (4335 rpm). Δ_0, 71.7 pounds (37,000 pounds, full-size); center of gravity 28 percent mean aerodynamic chord.

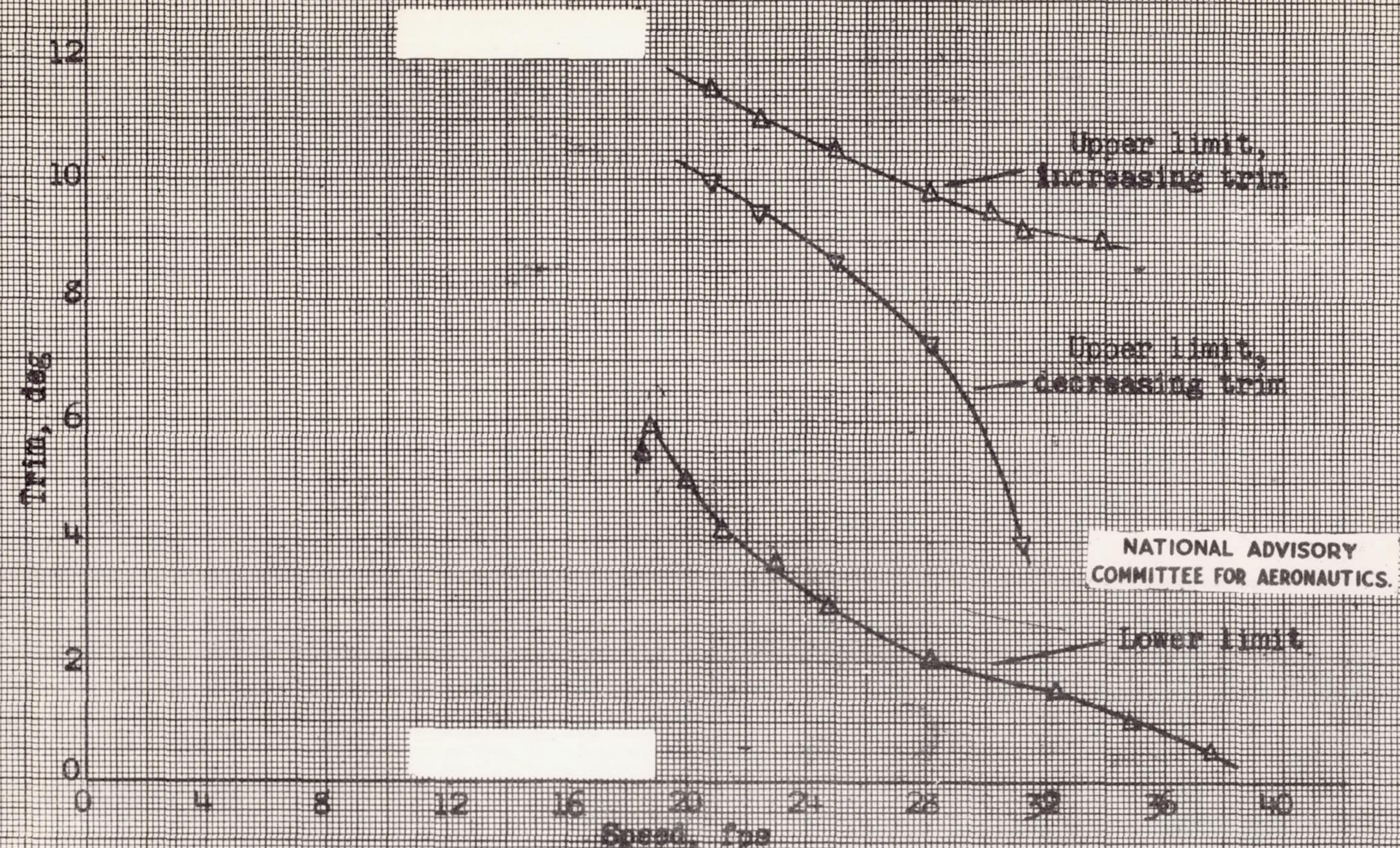


Figure 16.- Model 192. Trim limits of stability, with power (4335 rpm). Δ_0, 60.1 pounds, (31,000 pounds, full-size); a_s, -2° to wing chord.

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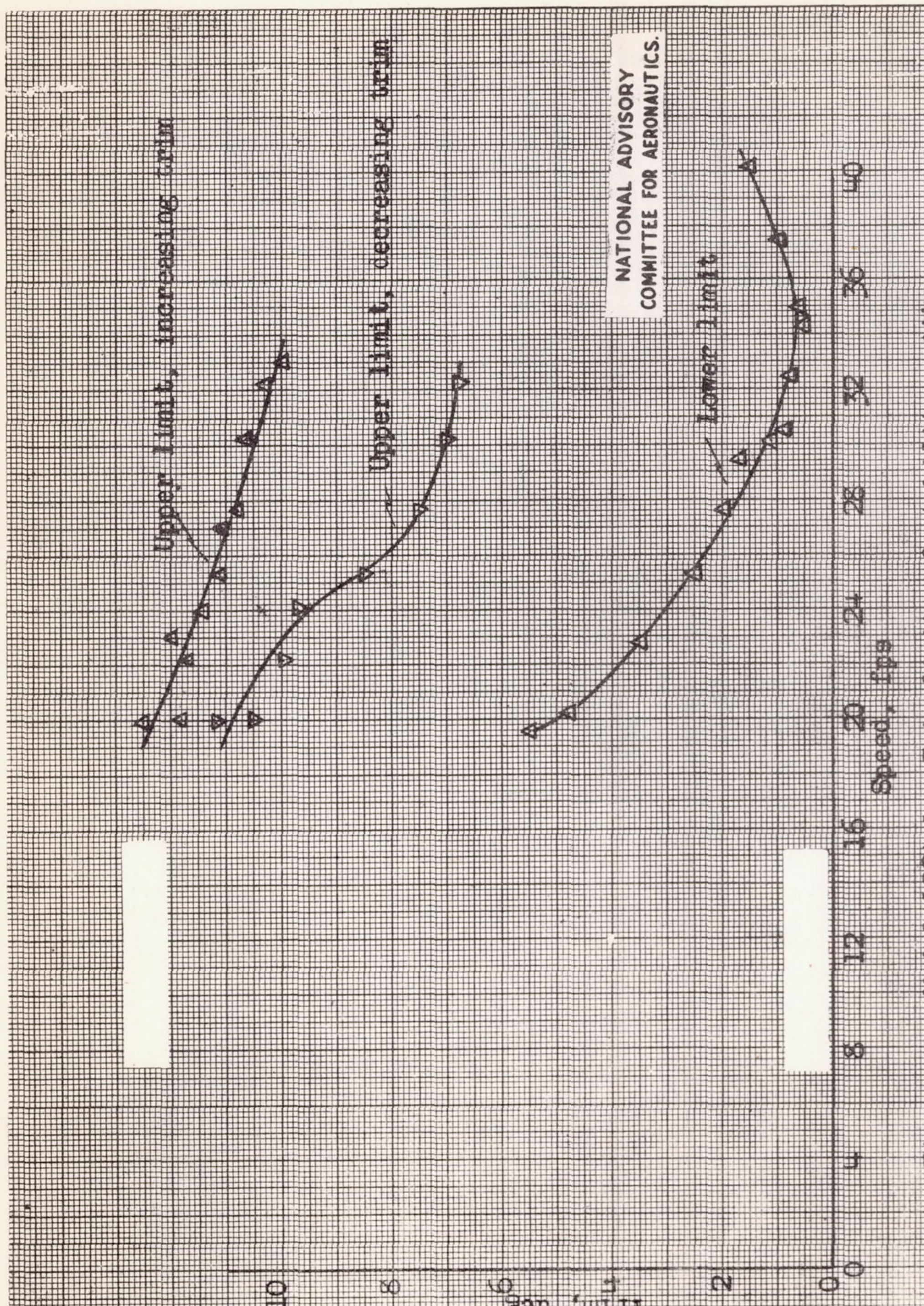

Figure 17.- Model 192A-1. Trim limits of stability, with power (4335 rpm). Δ_o, 60.1 pounds, (31,000 pounds, full-size); δ_f, -2 to wing chord.

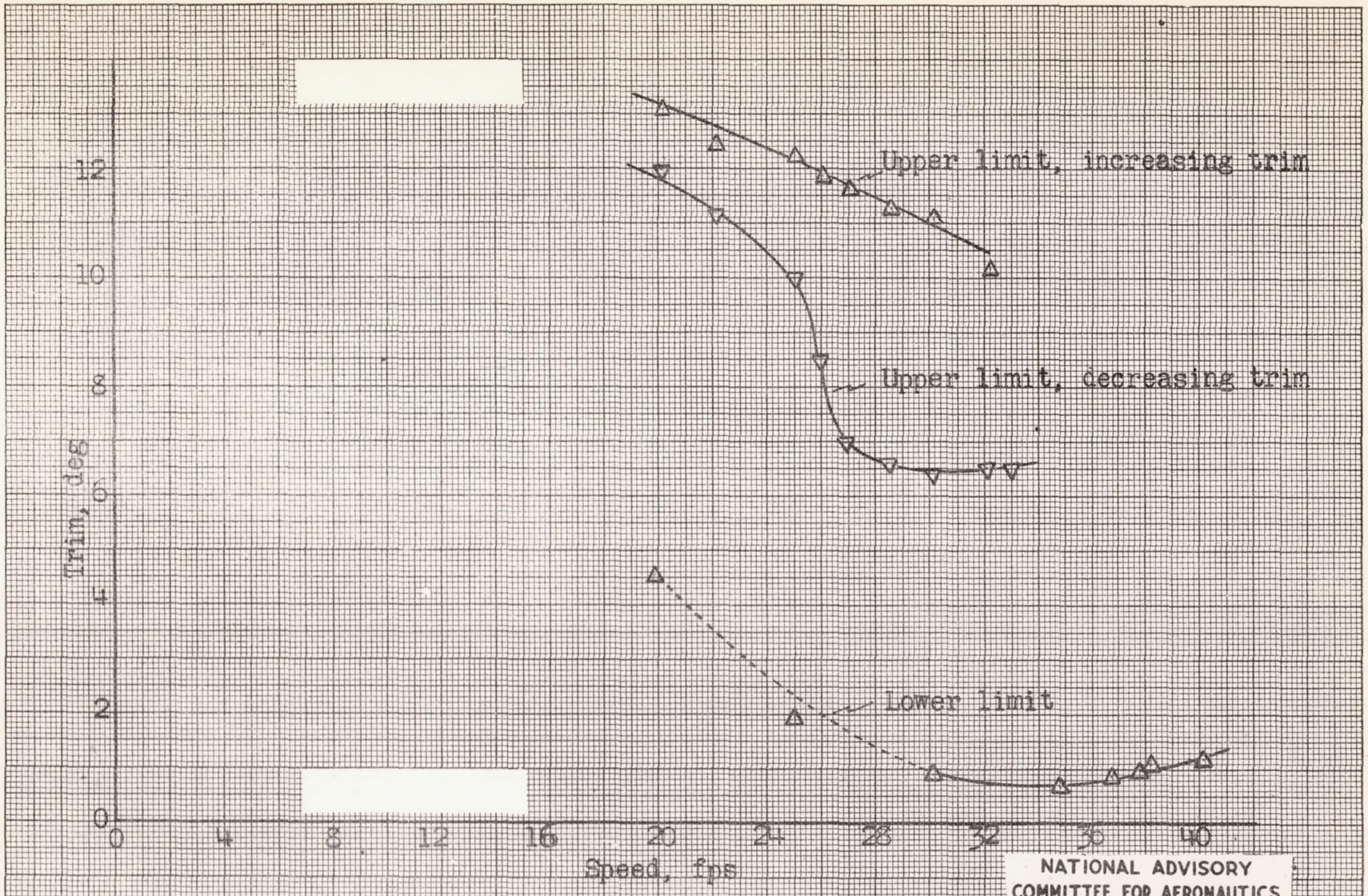

Figure 8.- Model 1928-1. Trim limits of stability, with power (4335 rpm). Δ_0, 60.1 pounds, (31,000 pounds, full-size); δ_s, -2 to wing chord.

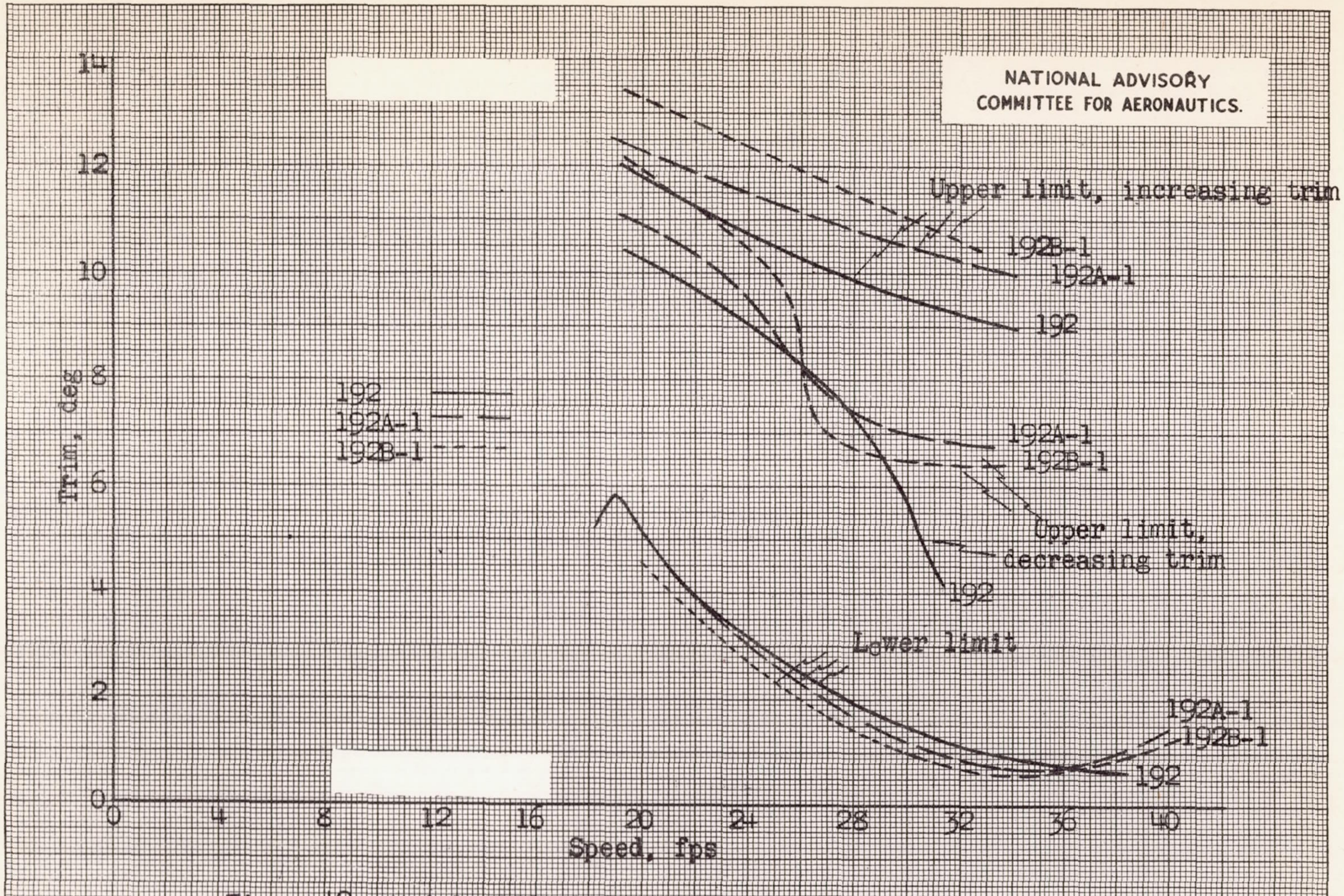

Figure 19.- Models 192, 192A-1, 192B-1. Trim limits of stability, with power (4335 rpm); Δ_o, 60.1 pounds. (31,000 pounds, full-size); δ_f -2° to wing chord.

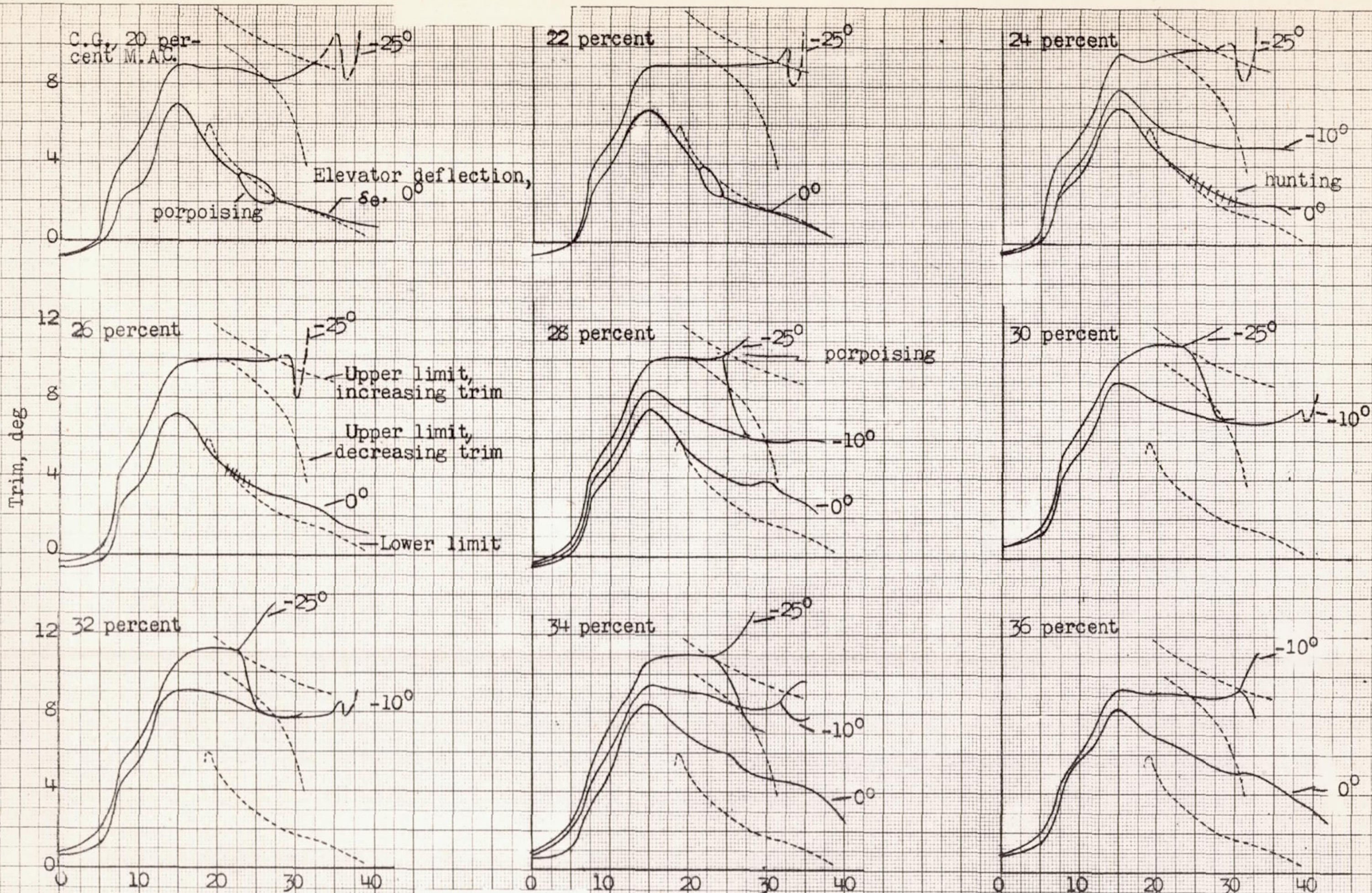

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Figure 20.- Model 192. Variation of trim with speed; with power (4335 rpm). Δ_0, 60.1 pounds, (31,000 pounds, full-size); δ_s, -2° to wing chord.

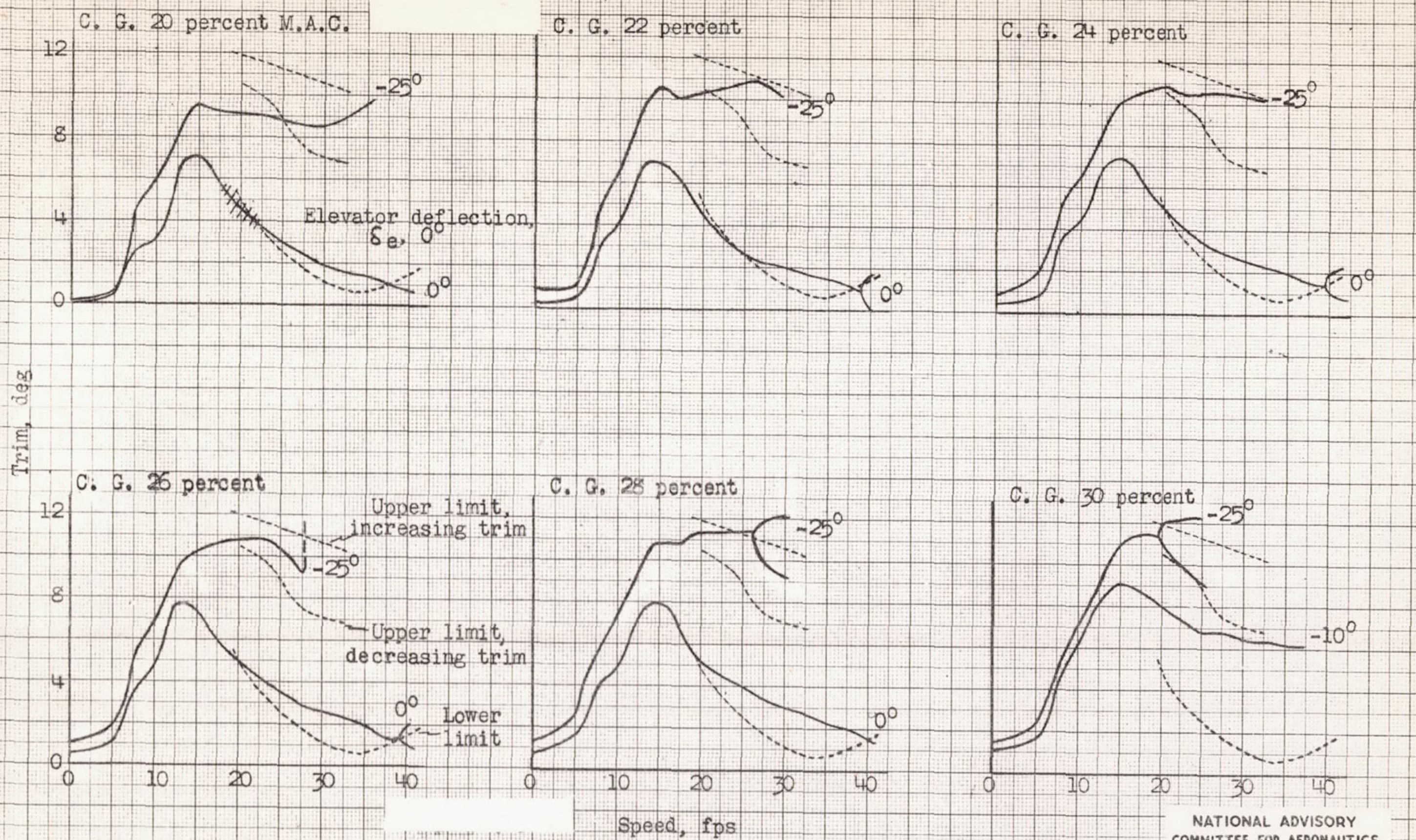

Figure 2 .- Model 192A-1. Variation of trim with speed; with power (4335 rpm). Δ_o, 60.1 pounds (31,000 pounds, full-size)

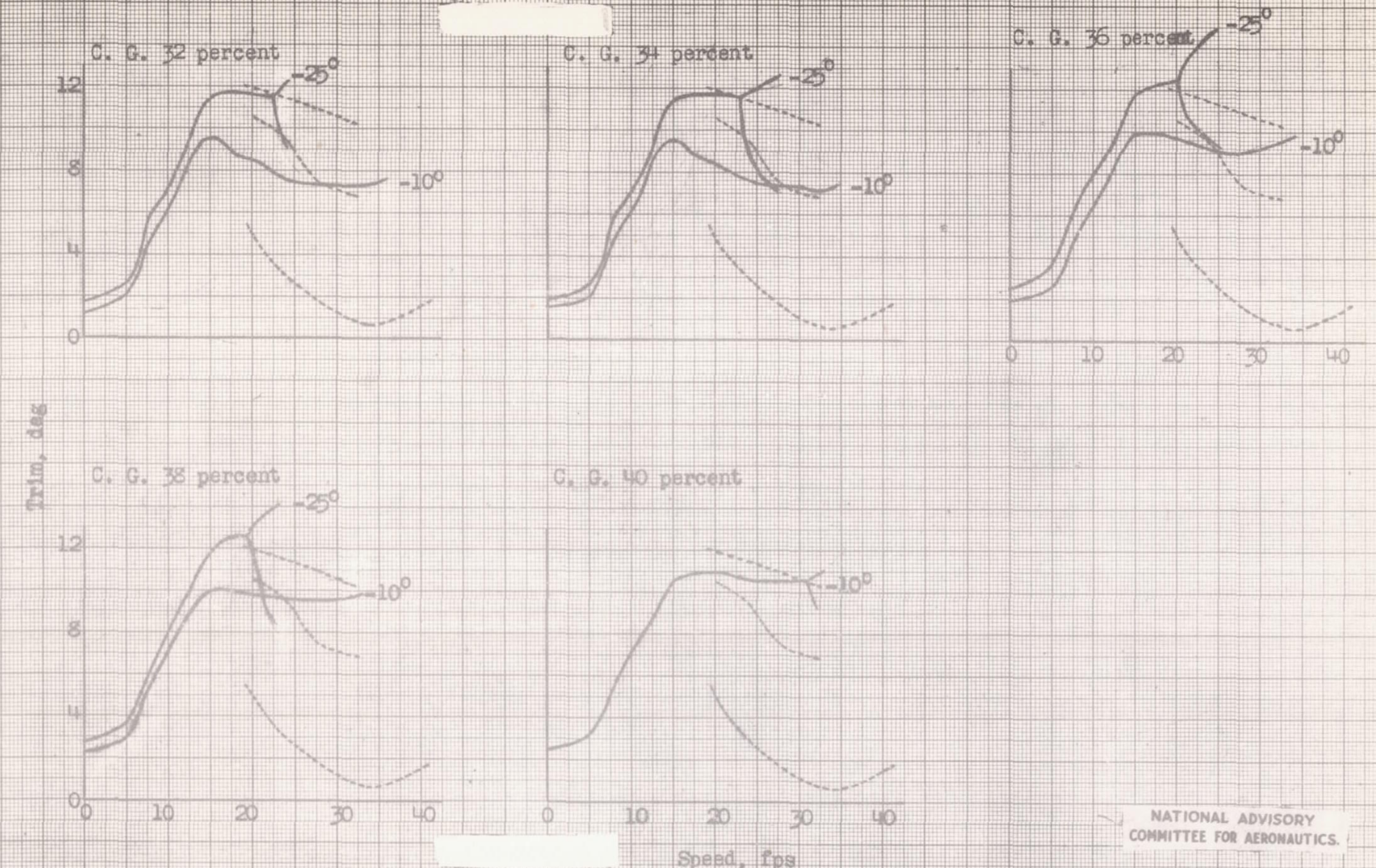

Figure 24.- Model 192A-1.- Concluded.

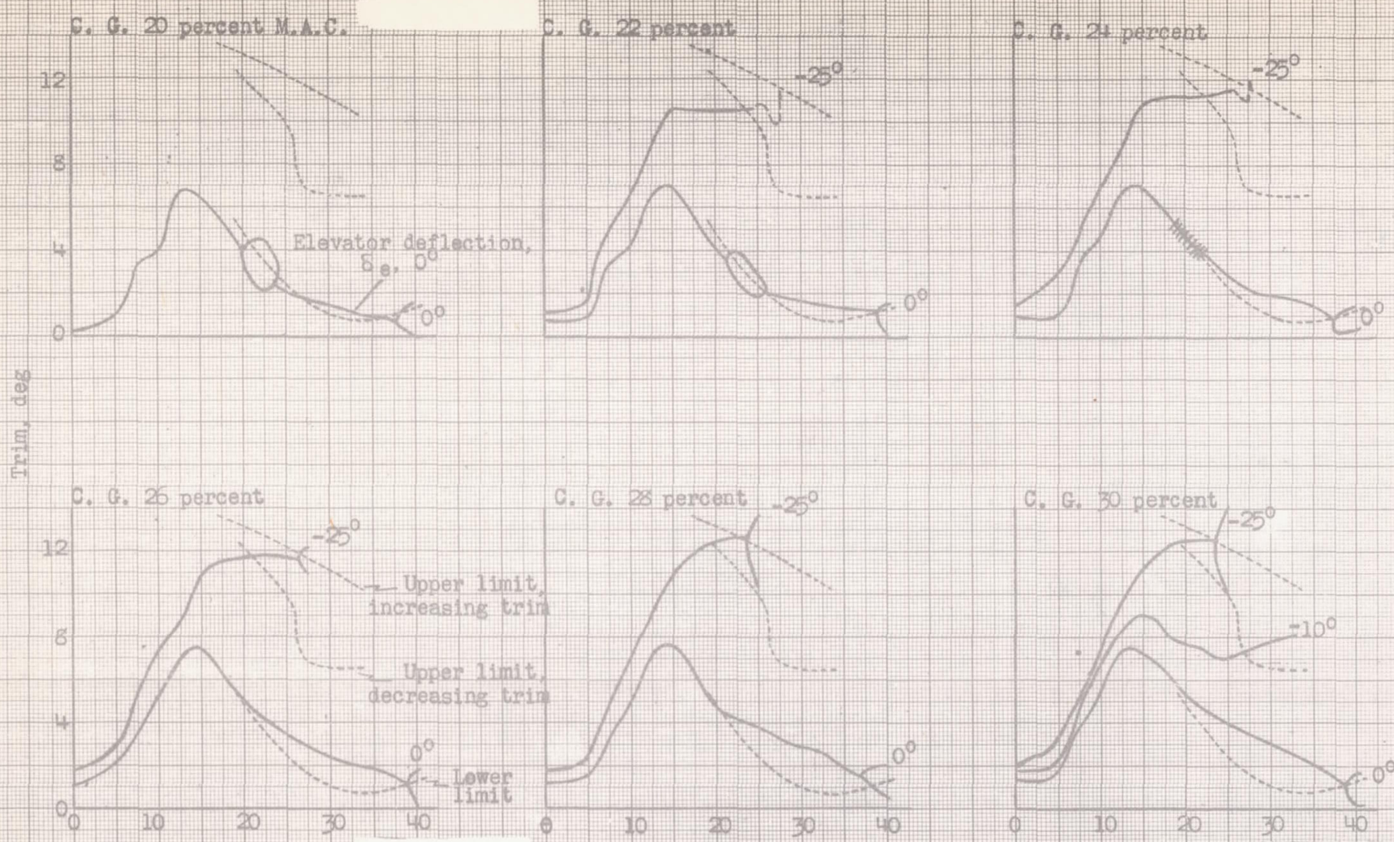

Figure 22.- Model 192B-1. Variation of trim with speed; with power (4335 rpm). Δ_0, 60.1 pounds (31,000 pounds, full-size).

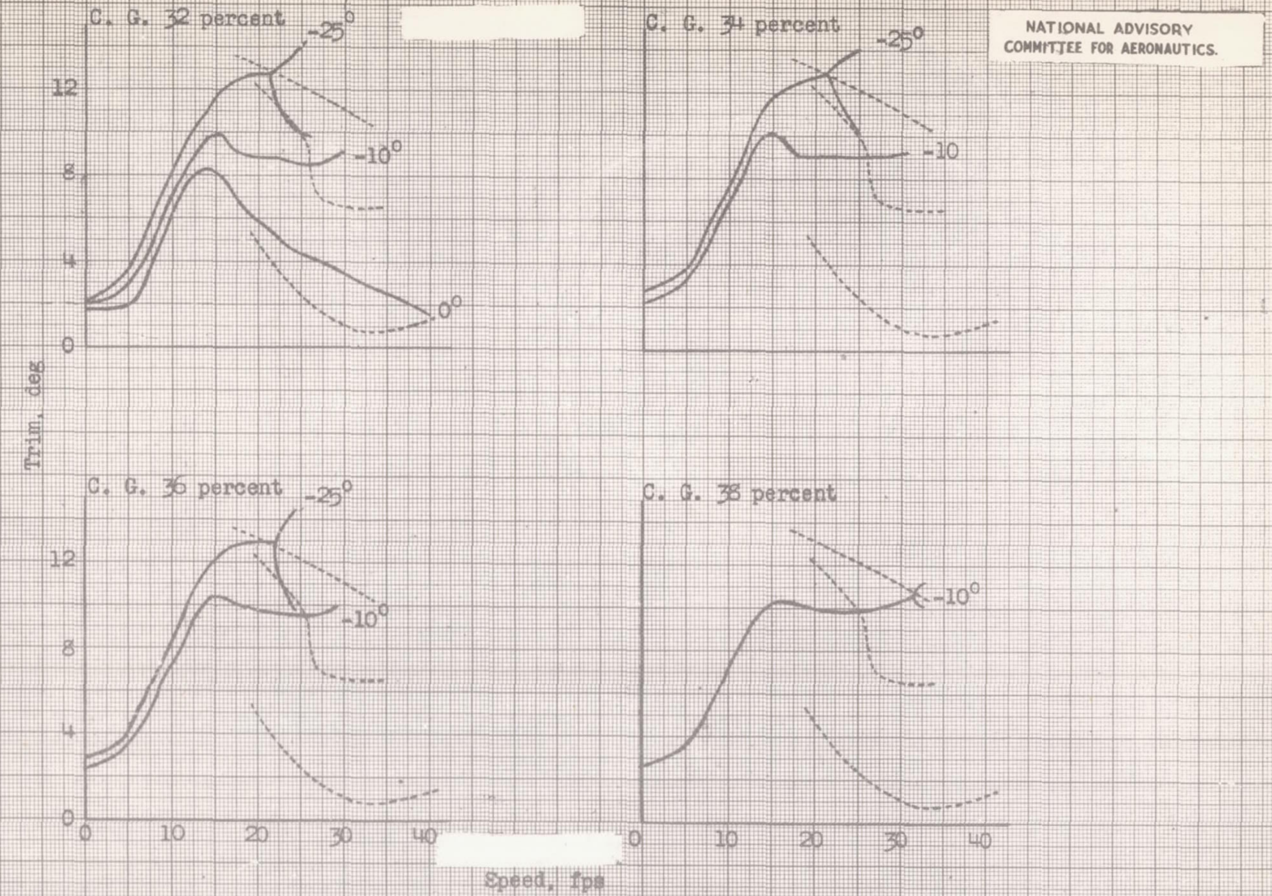

Figure 22.- Model 192B-1.- Concluded.

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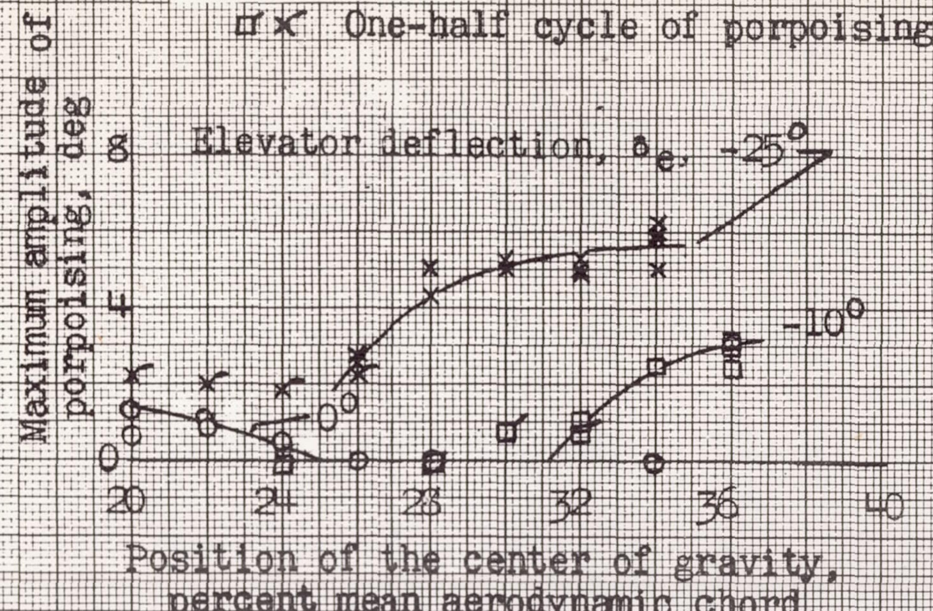

Figure 23.- Model 192. Variation of maximum amplitude of porpoising with position of the center of gravity; with power (4335 rpm). Δ_0, 60.1 pounds, (31,000 pounds, full-size); δ_s, -2° to wing chord.

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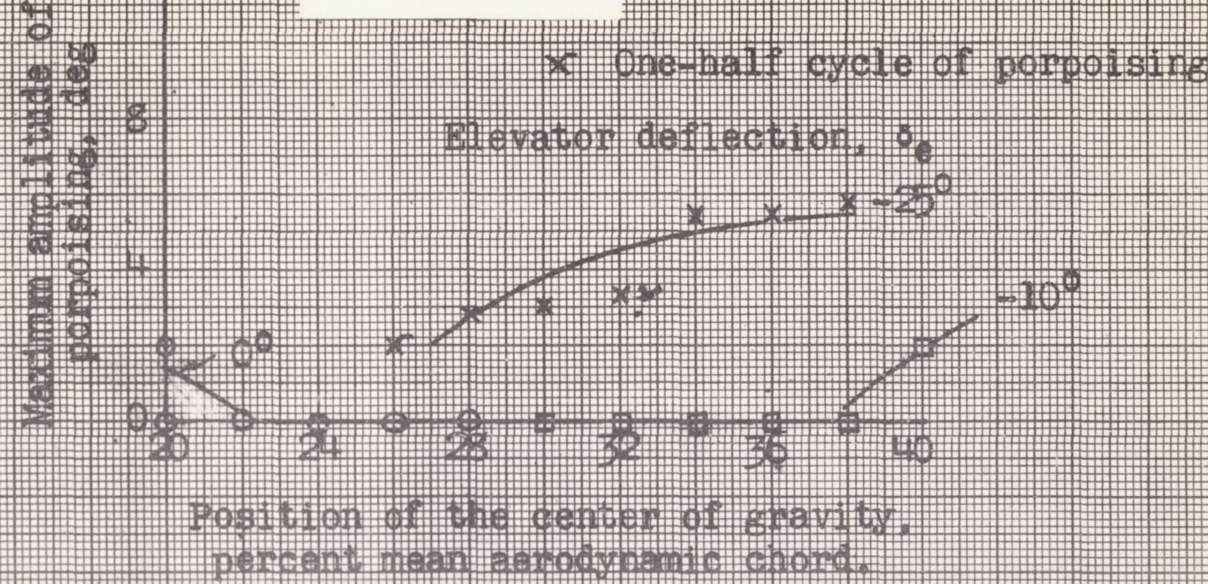

Figure24.- Model 192A-1. Variation of maximum amplitude of porpoising with horizontal position of the center of gravity; with power (4335 rpm); Δ_0, 60.1 pounds, (31,000 pounds, full-size); ϵ_s -2° to wing chord.

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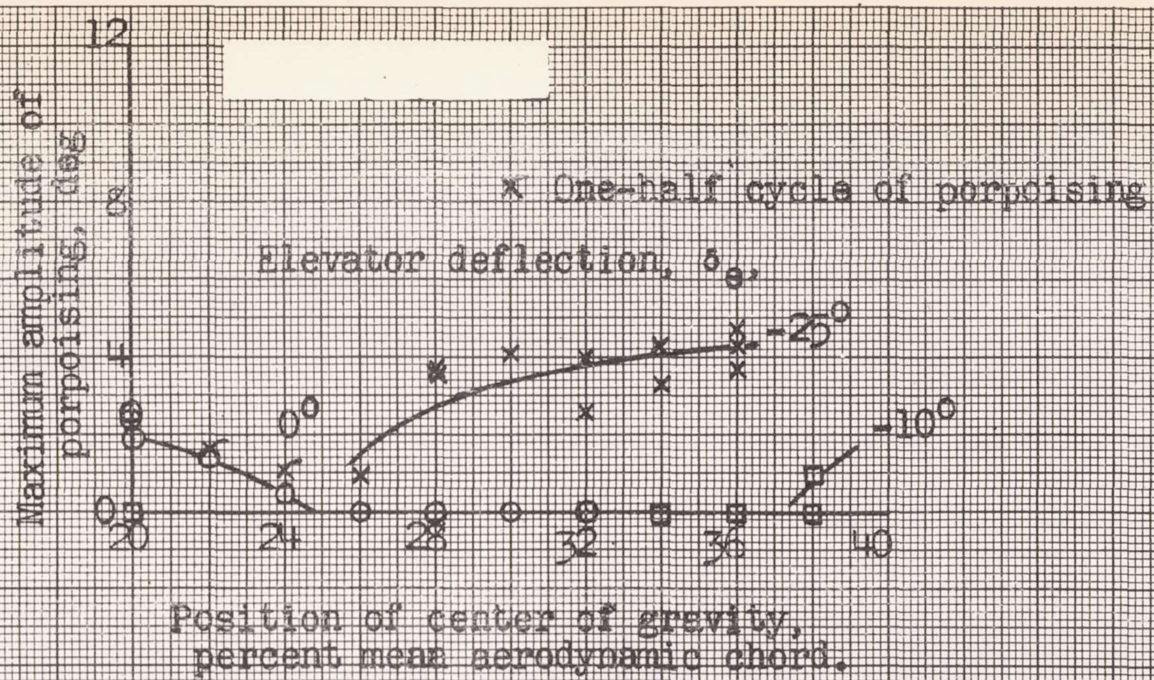

Figure 25.- Model 192B-1. Variation of maximum amplitude of porpoising with horizontal position of the center of gravity; with power (4335 rpm); Δ_0, 60.1 pounds (31,000 pounds full-size); δ_s -2° to wing chord.

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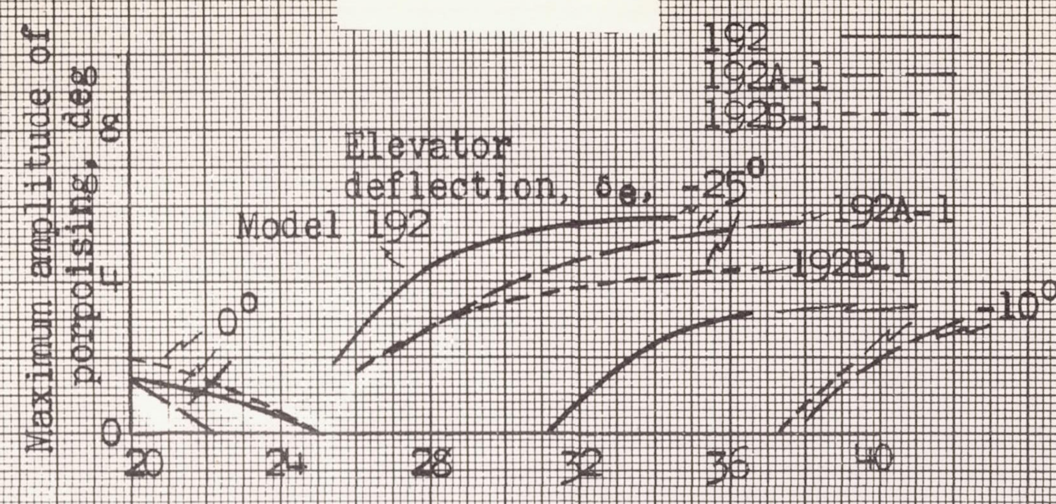

Figure26.- Models 192, 192A-1, 192B-1. Variation of maximum amplitude of porpoising with horizontal position of the center of gravity; with power (4335 rpm). Δ_o, 60.1 pounds (31,000 pounds, full-size). δ_s -2° to wing chord.

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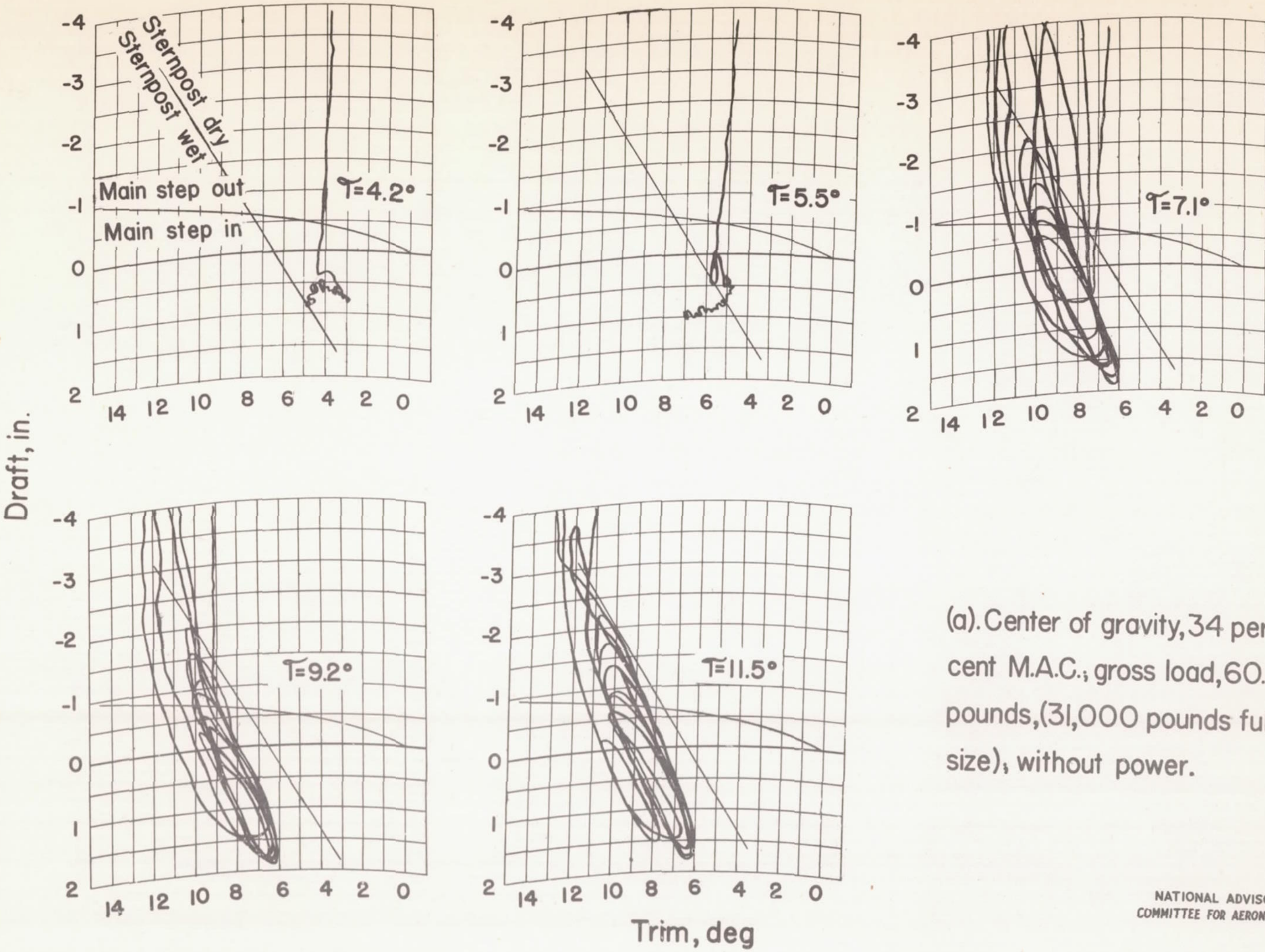

(a). Center of gravity, 34 percent M.A.C.; gross load, 60.1 pounds, (31,000 pounds full-size), without power.

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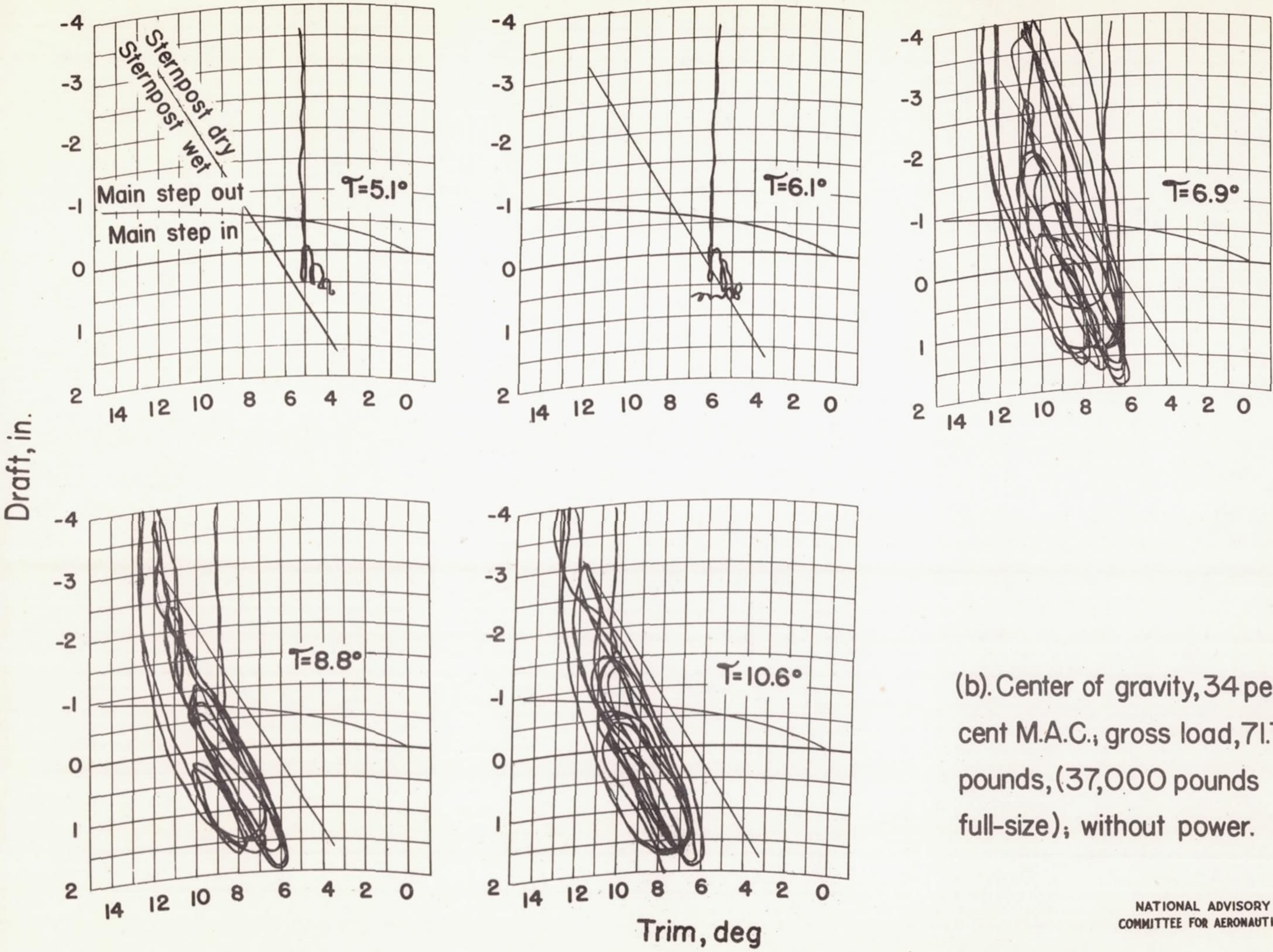
Figure 27 .- Model 192. Variation of trim and draft during landing.



(b). Center of gravity, 34 percent M.A.C.; gross load, 71.7 pounds, (37,000 pounds full-size); without power.

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Figure 27.- Model 192. Continued.

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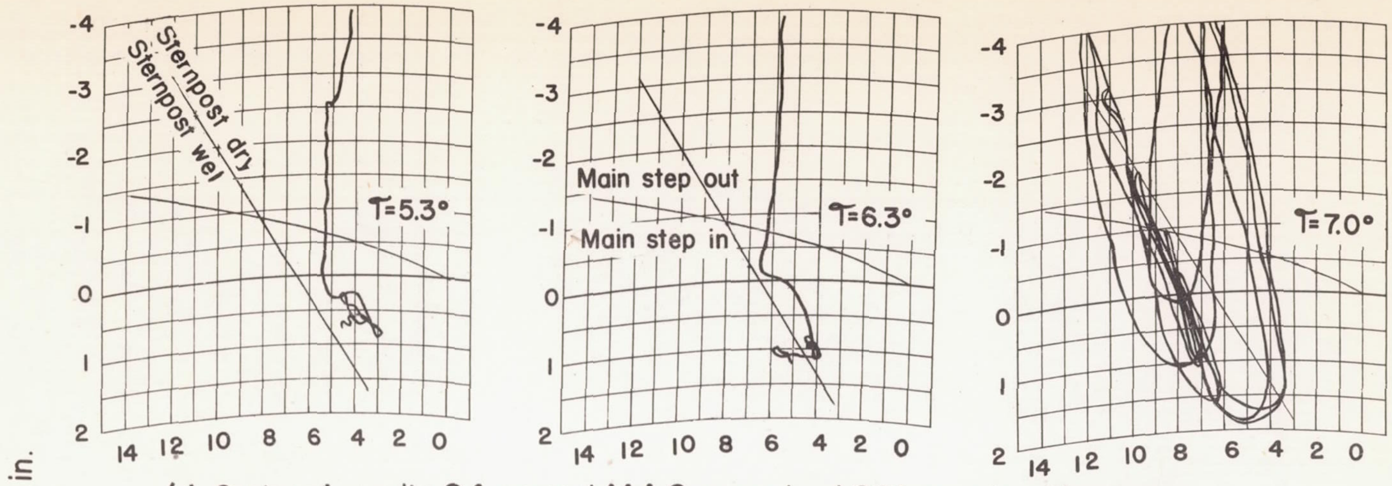
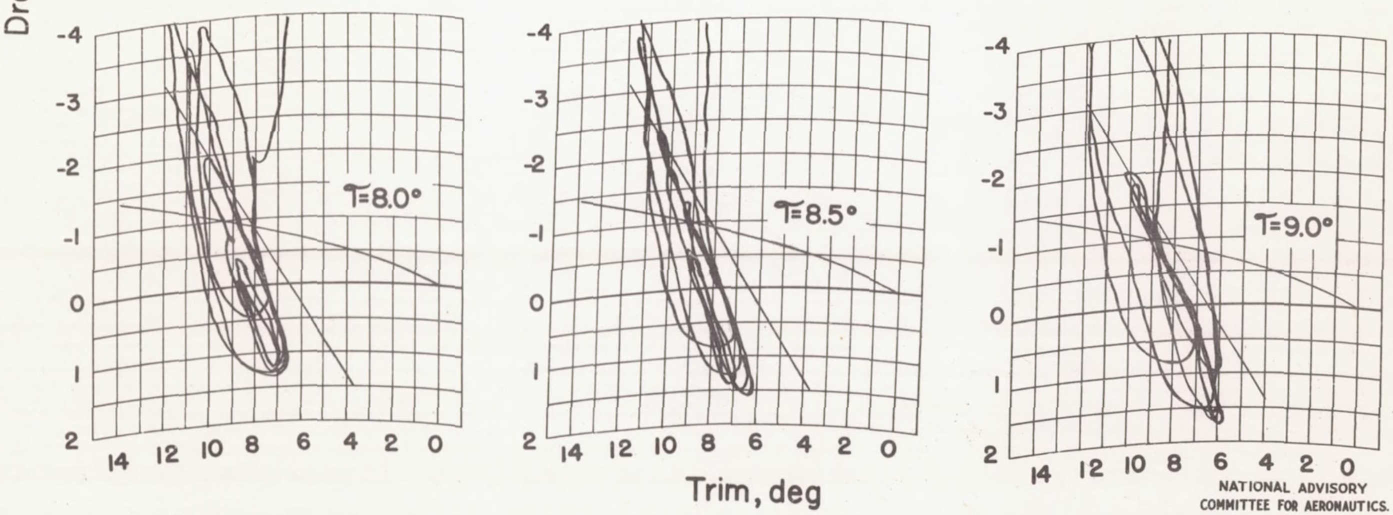


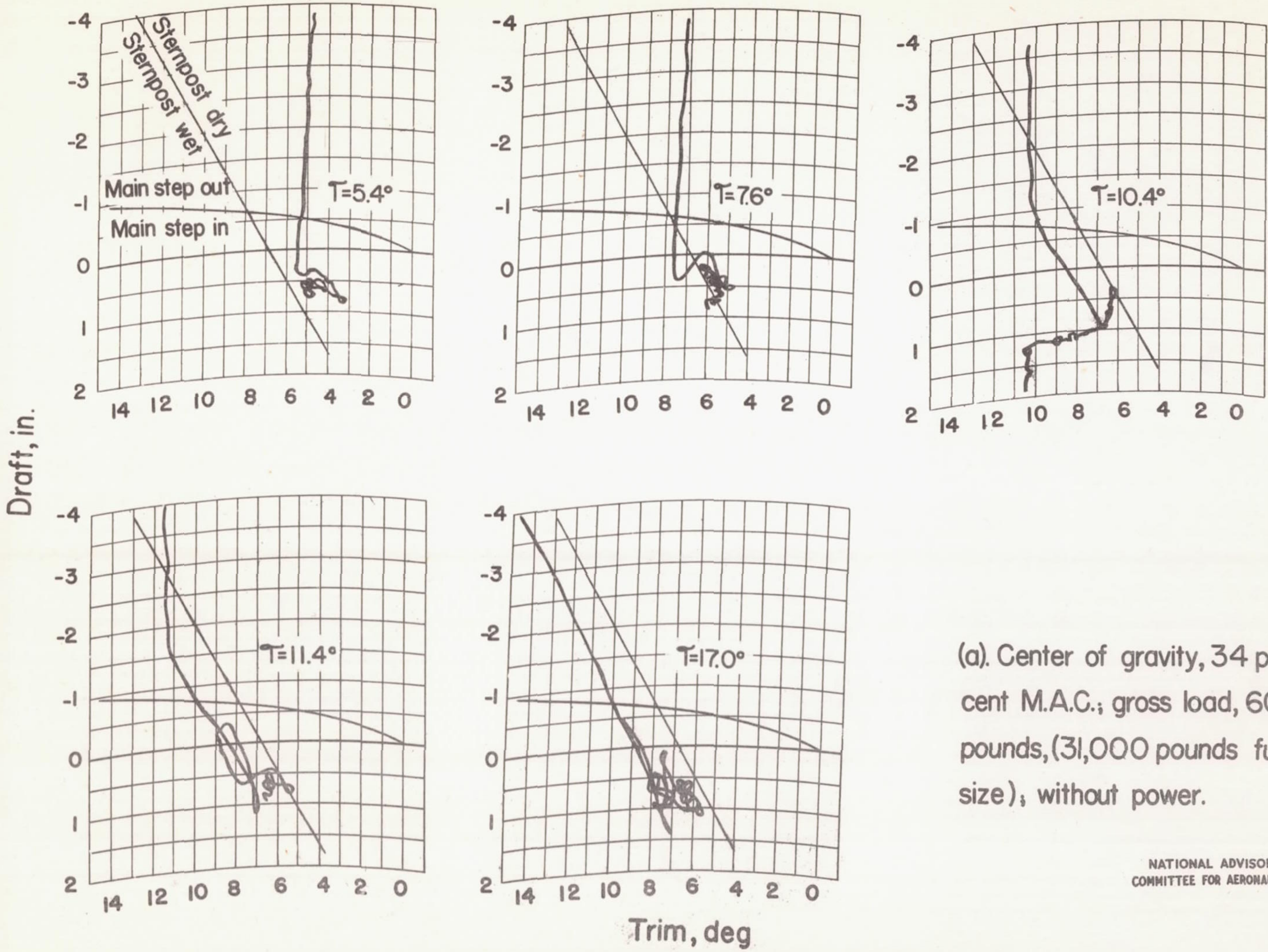
(c). Center of gravity, 24 percent M.A.C.; gross load, 60.1 pounds; without power.



(d). Center of gravity, 24 percent M.A.C.; gross load, 60.1 pounds; with half power.

Figure 27.- Model 192. Concluded.

MR No. L5C30



(a). Center of gravity, 34 percent M.A.C.; gross load, 60.1 pounds, (31,000 pounds full-size); without power.

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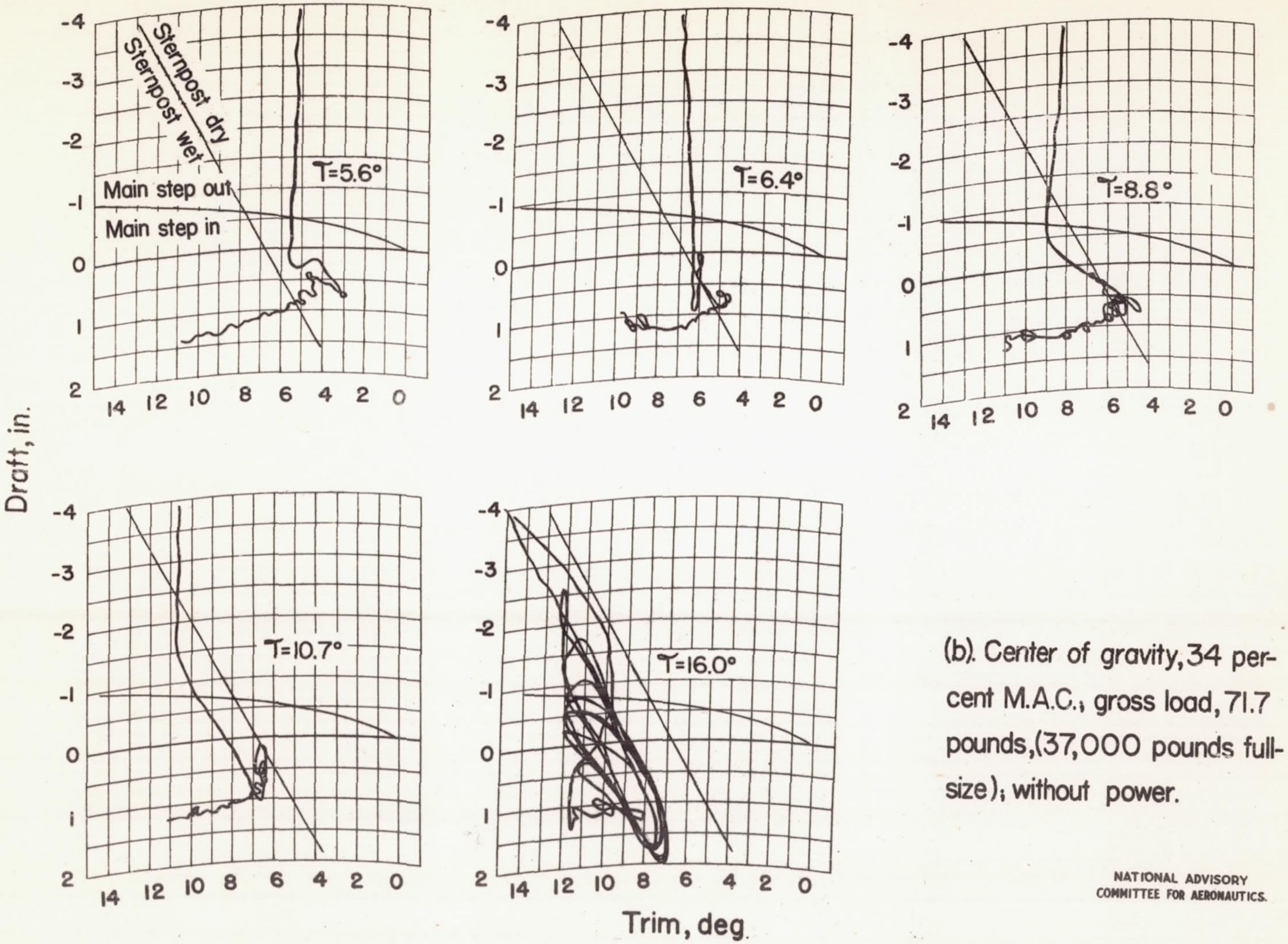
Figure 28 .- Model 192A-1. Variation of trim and draft during landing.



(b). Center of gravity, 34 percent M.A.C., gross load, 71.7 pounds, (37,000 pounds full-size); without power.

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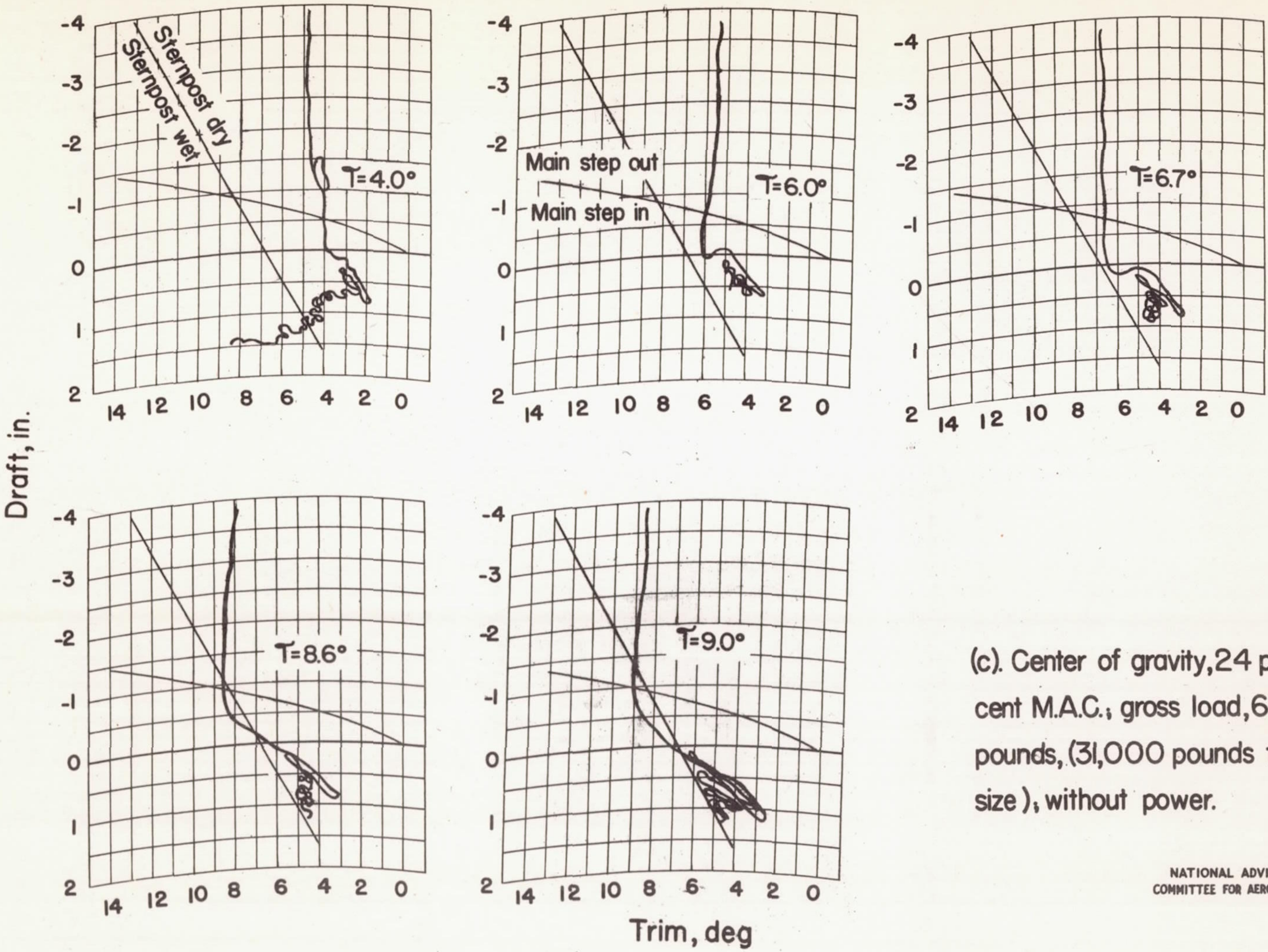
Figure 28 .- Model 192A-1. Continued.



(c). Center of gravity, 24 percent M.A.C.; gross load, 60.1 pounds, (31,000 pounds full-size), without power.

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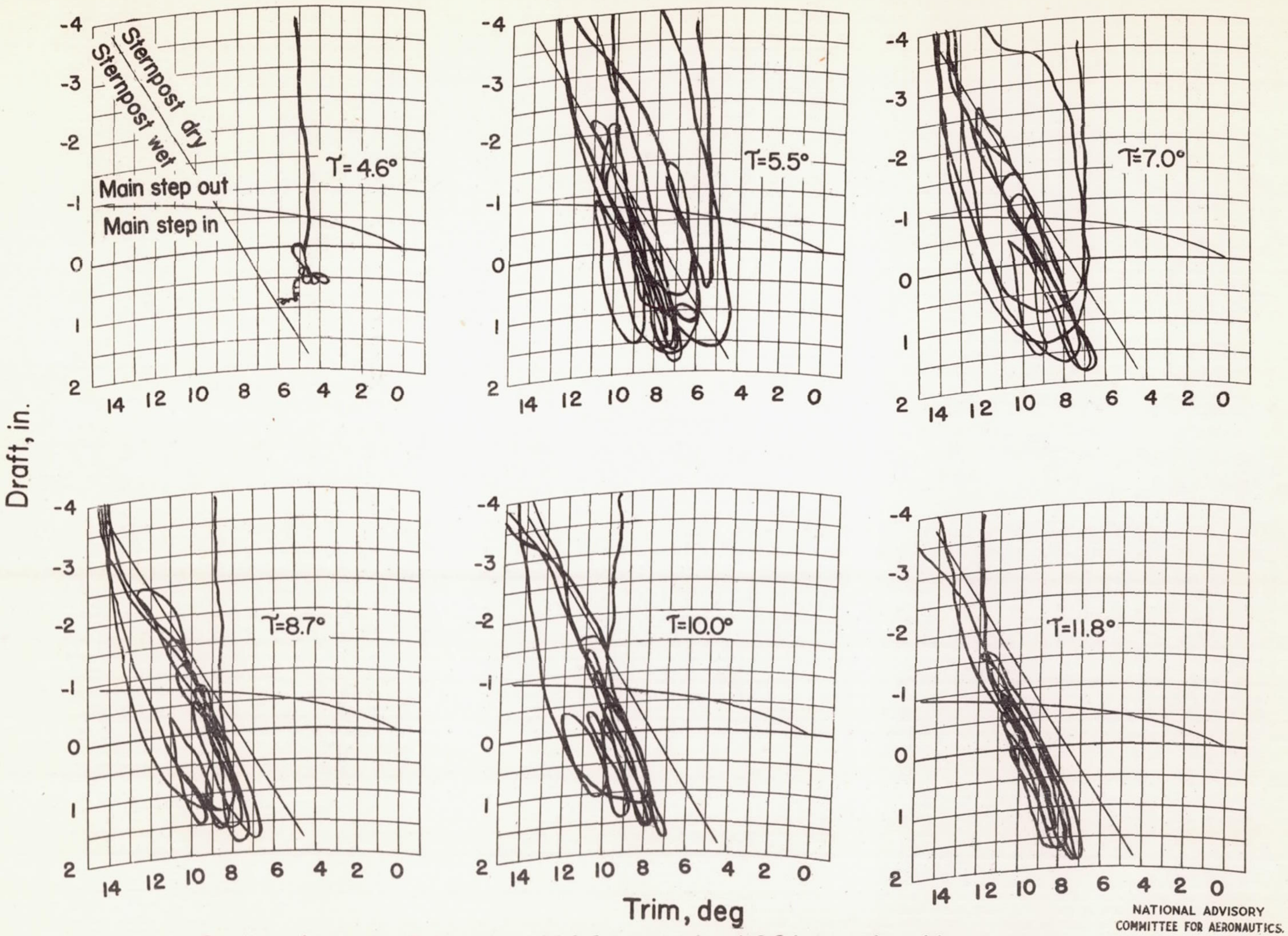
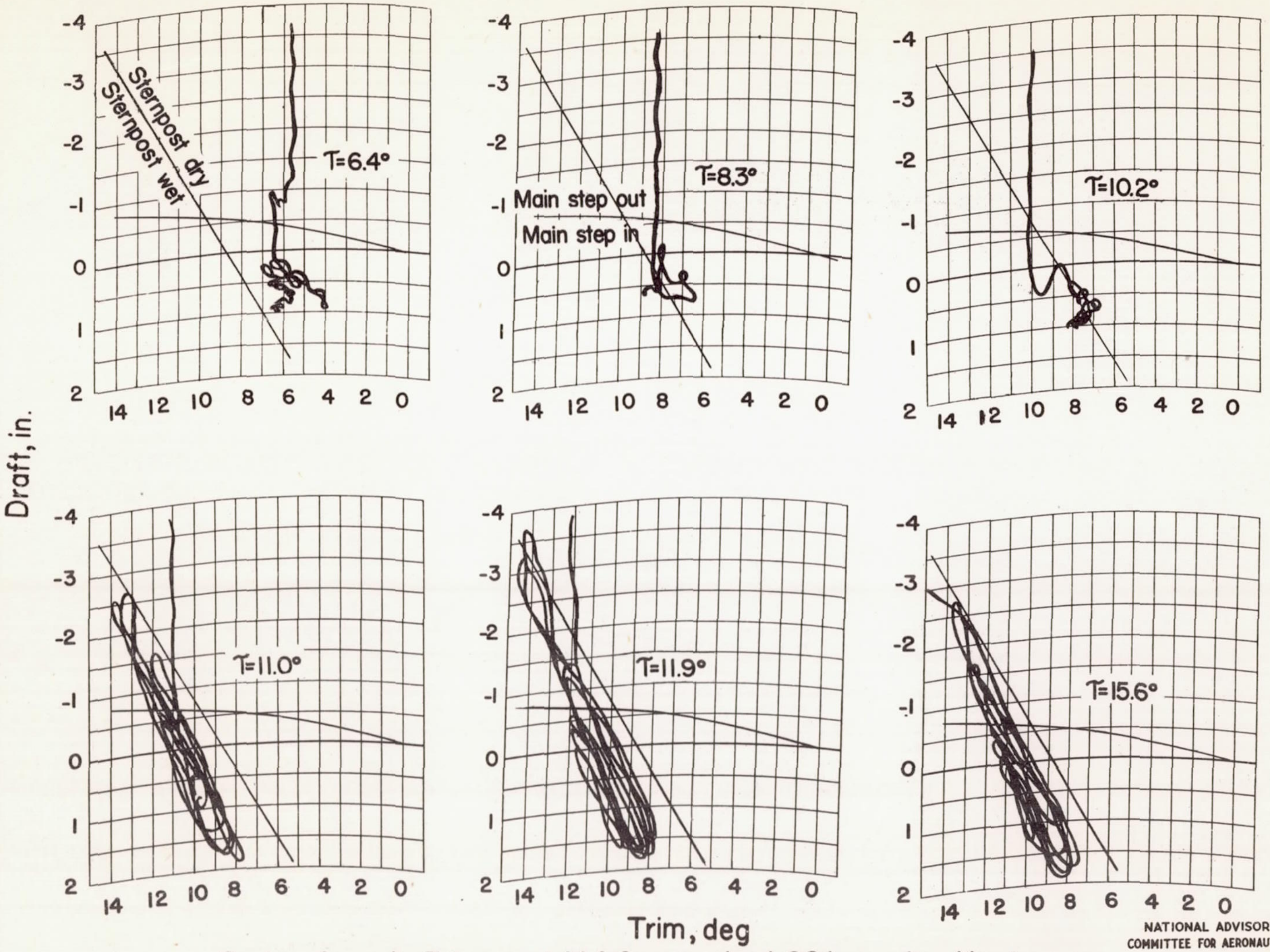
Figure 28 .- Model 192A-1. Concluded.

MR No. L5C30



Center of gravity, 34 percent M.A.C.; gross load, 60.1 pounds; without power.

Figure 29.- Model 192B. Variation of trim and draft during landing.



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Center of gravity, 34 percent M.A.C.; gross load, 60.1 pounds; without power.

Figure 30.- Model 192B-1. Variation of trim and draft during landing.